EAST ENGINEER
LIBRARY

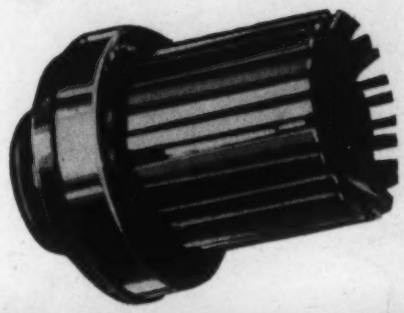
Materials & Methods

CERTAIN plastics applications call for a given property, or a given combination of properties, in greater degree than is available in general-purpose materials. Because Durez plastics are chemically compounded phenolic materials, they permit structural manipulations which make them extremely *versatile*. These illustrations suggest how the simplicity and economy of molding with Durez are being extended to special applications.

Quite often a discussion between the design engineer, the molder, and the Durez field man has produced ideas that improve products, reduce costs, and add new sales appeal. Besides our long experience in helping to solve plastics problems, we offer you today the advantages of greatly increased output and perfected control of uniformity. If you'd like to see what other manufacturers are accomplishing with Durez, let us send you "Durez Plastics News" each month. Durez Plastics & Chemicals, Inc., 147 Walck Rd., North Tonawanda, N. Y. *Export Agents: Omni Products Corp., 460 Fourth Avenue, New York 16, New York.*

For UNUSUAL plastics problems Durez has

special properties



RAYON SPINNING

HARSH ACIDS

HOT COFFEE

STEAM VAPOR

RAYON SPINNING. Heart of the machine that manufactures synthetic rayon from viscose is this thread-advancing reel. Operating under continuous tension, the Durez reel is unaffected by water, acid, desulphurizing liquid, bleaching solution, oil, or heat. Reel's fingers retain satin-smooth finish after years of operation.

HARSH ACIDS. Molded of another special-property Durez, these acid pump impeller parts can be machined, sanded, buffed. Chemical resistance enables the parts to give long service without corrosion.

HOT COFFEE. Like the glass bowl of the Cory coffee brewer, heat-resistant Durez plastic cover is chemically inert to boiling water infused with coffee, leaves the beverage flavor uncontaminated. Easy to clean . . . cool to touch . . . attractively modern. Note other Durez parts.

STEAM VAPOR. Durez housing of the DeVilbiss Electric Steam Vaporizer is resistant to alcohol and chemicals in medicinal spray, as well as to heat. Additional properties of the compound . . . moisture resistance and self-insulation . . . are also useful here.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

E. engin.
Engin.
Library
TN
1
.M58

MEMBER AUDIT BUREAU OF CIRCULATIONS

EDITORIAL STAFF

P. PETERS — Editor-in-Chief
DU MOND — Managing Editor
OLD A. KNIGHT — News Editor
NETH ROSE — Engineering Editor
CLAUSER — Associate Editor
S M. BARRY — Assistant Editor
NOR M. WOLFE — Assistant Editor
E HAWLEY — Art Director

ECUTIVE & BUSINESS STAFF

LIAM P. WINSOR — Vice-President and Publishing Director
NK J. ARMEIT — Production Manager
N ZELLNER — Circulation Manager
SCHMITT — Promotion Director
N T. FOSDICK — Market Research Director

DISTRICT MANAGERS

FOUNTAIN, New York
NK J. McKINLEY, New York
ANDOLPH LONG, Philadelphia
NARD S. KEARNEY, Cleveland

REPRESENTATIVES

M. McDONALD, Roy M. McDonald Co., San Francisco
ERT ALAND, Roy M. McDonald Co., Los Angeles

lished Monthly by Reinhold Publishing poration, 330 West 42nd St., New York , N. Y., U. S. A. Ralph Reinhold, Chair- of the Board; Philip H. Hubbard, Presi- t; H. Burton Lowe, Executive Vice Presi- t and Treasurer; G. E. Cochran, Vice ident and Secretary; William P. Winsor, e President; Francis M. Turner, Vice ident. Price 50 cents a copy. Payable in ance, one year, $2.00; two years, $3.00; ee years, $4.00; five years, $5.00 in U. S. Possessions, Canada and Pan American on. $2.00 extra for each year in all other ntries. (Remit by New York Draft.) Copy- t, 1948, by Reinhold Publishing Corpo- on. Printed by Lotus Press, Inc., 508 st 26th St., New York 1, N. Y. All rights erved. Reentered as second class matter v. 14, 1945, at the Post Office at New k, N. Y. under the Act of March 3, 1879

Materials & Methods®

VOLUME 28, NUMBER 1 • JULY, 1948

FEATURE ARTICLES

ELIMINATION OF STEEL BASING POINT SYSTEM
Harold A. Knight 51

HEATING METALS BY INDUCTION, HIGH-SPEED GAS METHODS
H. R. Clauser 55

ELECTRICALLY-CONDUCTIVE RUBBER
A New Materials Preview 60

MATERIALS AT WORK 62

NEW MAGNESIUM ALLOYS OFFER SUPERIOR PROPERTIES
Kenneth Rose 66

COPPER-ALUMINUM JOINTS MADE BY UPSET WELDING
R. T. Gillette 70

WOODEN DOWELS SOLVE PROBLEMS IN BRAZING STEEL
S. De Domenico & A. Squire 74

MATERIALS & METHODS MANUAL NO. 39

PERMANENT MOLD CASTINGS
Herbert Chase 75

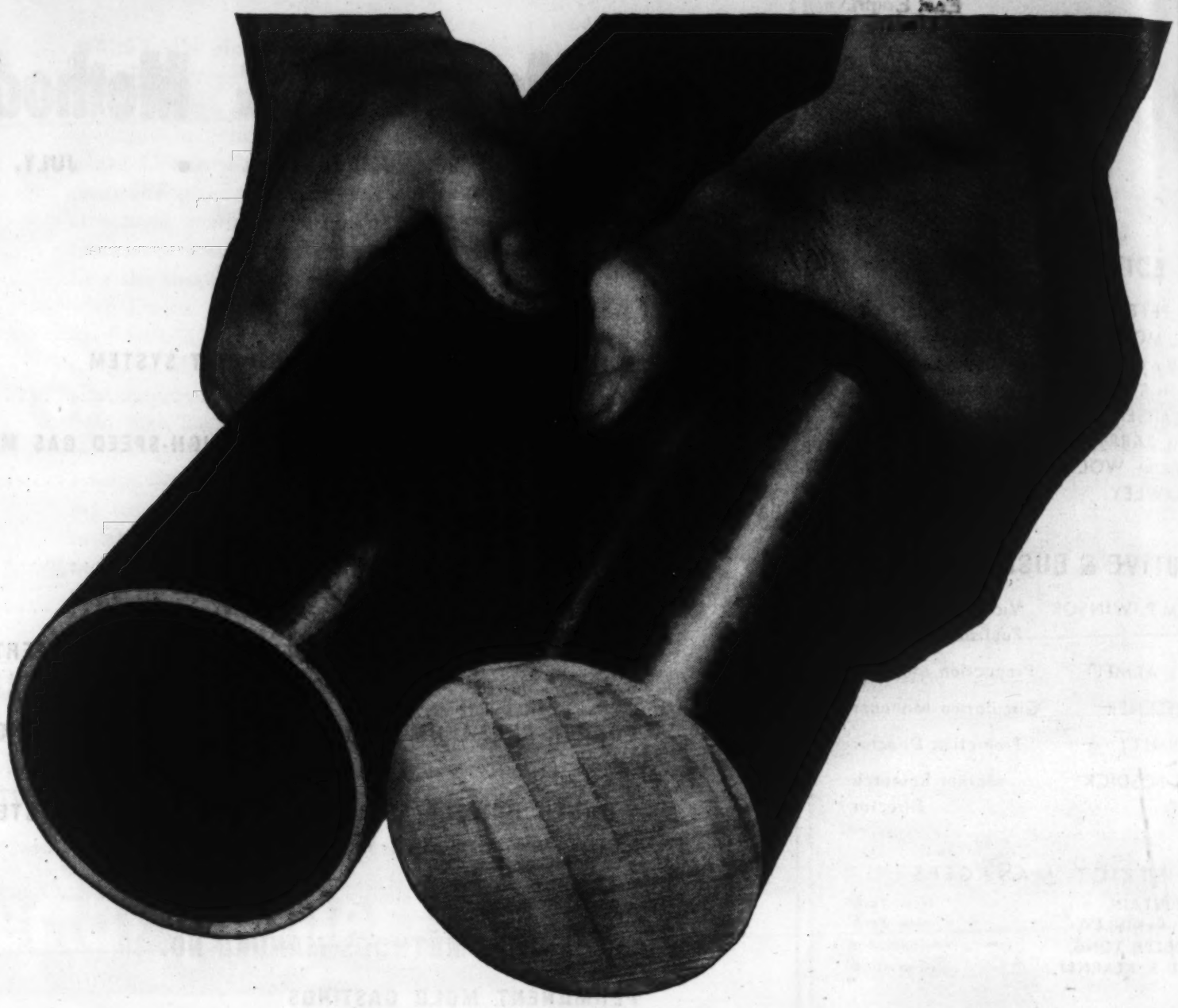
ENGINEERING FILE FACTS

NO. 163—METALS FOR USE WITH HIGHLY CORROSIVE MEDIA 87

DEPARTMENTS

The Materials Outlook 3
Editorial 49
Materials & Methods Digest 91
Manufacturers' Literature 99
New Materials and Equipment 103
Meetings and Expositions 144
Book Reviews 146
Advertisers and Their Agencies 182
The Last Word 184

NEXT MONTH: Science Making Progress in Combatting Corrosion Losses . . . Step Brazing to Join Dissimilar Materials . . . A New Spinning Technique Used to Form Large Stainless Steel Shapes . . . A Heat-Treatable Resistance Alloy . . . Control of Carbon in Steel Heat Treating Through Gaseous Equilibrium . . . Unwoven Cotton Used as Basis for Heavy-Duty Gears . . . BEARING METALS (Materials & Methods Manual No. 40)



Hollow or Solid . . .

How Do You Want Them?

Do you need cold drawn mechanical tubing or cold finished steel bars? We have both—and many other steel products, all in stock for quick shipment.

True—great demand sometimes depletes the supply of a kind or size here and there. Still, we probably have the largest over-all steel stocks in the country, and our cold finished bar and cold drawn tubing stocks are particularly good. Round bars range in size from 1/16" to 10" with analyses suitable for every application. Ryerson mechanical tubing stocks include sizes from 1/8" to 10½" O.D. in many wall thickness.

You can be confident of high quality steel when you draw on Ryerson stocks. For example, we carefully check cold finished bars for roundness, mechanical tubing for concentricity and both products for straightness, finish and size accuracy.

So whether you want them solid or hollow—whether you need bars or tubing—or other carbon, alloy and stainless steel products, call Ryerson. We are ready and anxious to work with you.

Joseph T. Ryerson & Son, Inc. Plants: New York, Boston, Philadelphia, Detroit, Cincinnati, Cleveland, Pittsburgh, Buffalo, Chicago, Milwaukee, St. Louis, Los Angeles, San Francisco.

PARTIAL LIST OF PRODUCTS

BARS—carbon & alloy, hot rolled & cold finished
TUBING—Seamless & Welded mechanical & boiler tubes
STRUCTURALS—I beams, H beams, channels, angles, etc.
PLATES—incl. safety floor plate
SHEETS—hot & cold rolled
STAINLESS—Allegheny Metal sheets, plates, bars, etc.
MACHINERY & TOOLS—for metal working

RYERSON STEEL

The MATERIALS OUTLOOK...

LATENT DEMAND FOR ALUMINUM REPORTED—Independent studies of prospective aluminum uses have indicated an astounding latent demand apart from the contemplated big uses in building construction. Shortage of the metal appears to be the only reason aluminum is not now being employed for petroleum pipe lines. Car building is possibly next in line on a tonnage basis. Army engineers are favoring aluminum truck bodies. The metal has also been favorably considered for bridge crane girders instead of steel. Light aluminum ladders have demonstrated superiority over wooden ladders. Some recent government purchases of lockers have specified aluminum. Many small hardware items now made in brass or plated steel, and many so-called "accessory" items, such as compacts, all manufactured in millions and totalling large tonnage, can be made economically in aluminum because of the ease of fabrication and finishing. At least two companies are ready to push aluminum electric wire instead of copper when it is available in quantity. Sculptor Lawrence Stevens says that aluminum should replace bronze for large statues. Aluminum alloy has proved successful for cans and boxes for tooth powder, tobacco, cocoa, and other items. British naval architects are advocating use of aluminum in ship superstructures to save weight, lower the center of gravity, and reduce beam and displacement. But 8 to 10 kilowatt hours are needed per pound of aluminum produced, and it will take two to three years to build power plants after the arguments are all ironed out.

ALUMINUM BRONZE IN FORMING DIES—Some surprising results have been demonstrated with drawing and forming dies made of aluminum bronze instead of the standard tool steels generally used. One bronze producer has developed a special grade of bronze that gives exceptional hardness and wear resistance when heat treated. One of the points of superiority over steel is that the formed or drawn parts do not seize in the die and there is no galling, so that the bronze dies have given as much as five times the service life of steel dies.

TITANIUM SUPPLIES INCREASE—In view of the rapid expansion in uses for titanium, recent statistics of supply are encouraging. Thus, domestic production and imports of ilmenite in 1947 were both at all-time highs, as was domestic output of rutile, another commercial titanium ore. Domestic ilmenite output was 19% higher than in 1946 and 9% over the previous peak in 1945. Shipments to consumers in 1947 were also at a new high and inventories at the end of 1947 were greater than ever before and would support the 1947 peak consumption rate for almost a year, unaided. Moreover, du Pont has signed a long-term lease for state-owned ilmenite property near Starke, Florida, large scale mining to get under way promptly.

CARTELS WORK FOR HIGH PRICES—Cartels will have to be reckoned with again and will influence prices towards the high side on commodities in which we do major importing, such as mercury and cobalt. Several of these cartels have been revived to prewar strength, their purpose being to limit production and keep prices high. They are hardly consistent with our E.R.P. program, which strives to create plenty instead of scarcity.

COBALT CONSUMPTION RISES—Speaking of cobalt, in the first quarter of 1948 its use in permanent magnet alloys gained 19% over the preceding quarter and proved the largest single application. Its second largest application was for cast cobalt-

(Continued on page 4)

The Materials Outlook *(Continued)*

chromium-tungsten alloys, which used 21% more cobalt than in the preceding quarter. There was also a gain in use in cemented carbides and magnet steel.

PURE DUCTILE ZIRCONIUM—The Foote Mineral Co. has perfected a process for manufacture of pure ductile zirconium, used largely in vacuum tubes as a "getter" or gas absorber when heated. In fabricated form it is expected to find extensive use in chemical equipment. A sheet 5½ by 3¼ in. sells for about $5.

TOO MUCH METAL TO EUROPE?—An American metal producer, returned from Europe, claims he found we are planning to send more metal abroad under the European Recovery Program than Europeans need or can digest. He said that Italian governmental officials and industrial leaders were astounded by the amount of copper earmarked for Italy, they stating that they cannot possibly use so much.

ELGILOY IN NEW USES -"Elgiloy," the new alloy developed by the Elgin National Watch Co. for watch main springs, is being made available to other industries, including heavy manufacturing and metal industries, food processing, paper and pulp. Sponsors claim marked superiority to other stainless metals in resistance to corrosion by mineral and organic acids and the chlorides. As to strength and toughness, they say it exceeds the best of carbon and stainless steels, as well as in corrosion resistance. Live possibilities are for scales, cameras, automobile springs, fishing equipment, cutlery and compressor valves. It is manufactured in strips up to 2½ in. wide, or as round wire.

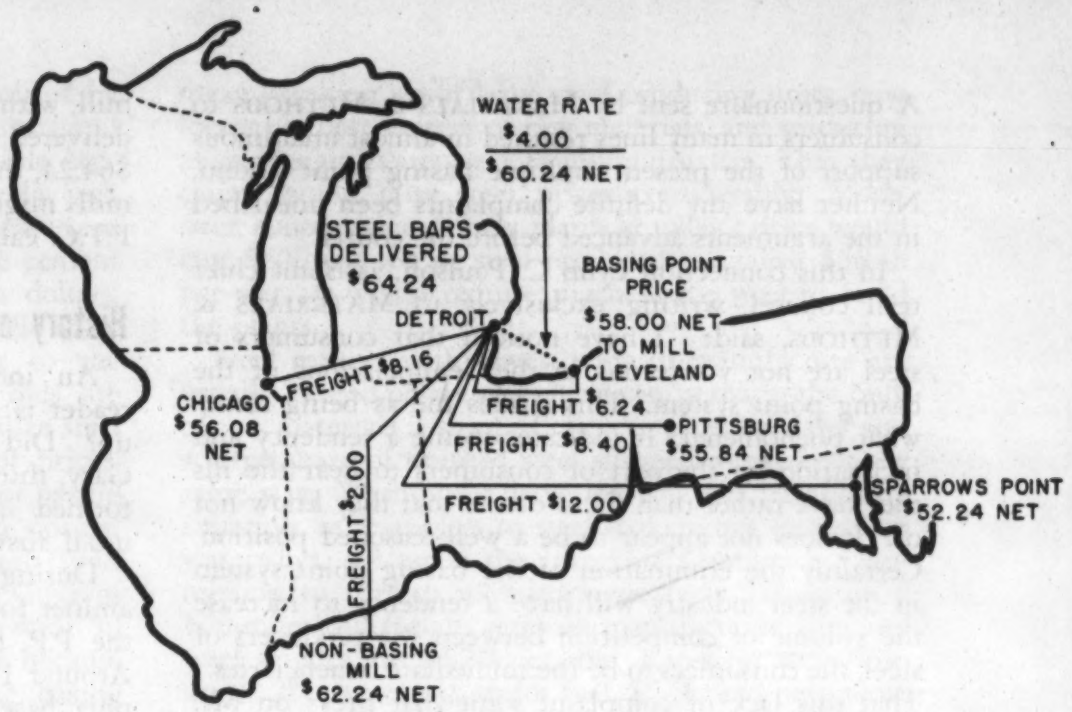
TWICE AS MUCH OXYGEN—Total yearly production of low-purity oxygen by the seven large plants now in construction will run 40 billion cu. ft., or twice that produced at the wartime peak. Costs range down from $7.02 per ton to $3.67, the latter for a plant producing 1000 tons daily, the figures excluding the price of steam and other power-generating facilities. Five potential uses for the new oxygen are: production of synthetic liquid fuels, iron and steel, sulfuric acid, manufactured or reformed natural gas, and chlorine.

REVOLUTIONARY STEEL PROCESS—The British report a new steel process which may prove as revolutionary as Bessemer steel, the new process having been tried out at Wolverhampton, England. With it, rolling mills could cast their own steel billets on the spot without buying them from an outside mill. The rudimentary principle, it is reported, is fusing of light scrap with other ferrous materials, melting the mixture and pouring into molds. When the mold cools it is opened—and there is the steel ingot ready for reheating and rolling into strip and conduit tubing.

HIGHER ZINC PRICE COMING—The failure of the Russel bill to pass Congress will probably result in higher zinc selling prices. The bill proposed to Government-subsidize the high cost producers, particularly in the tri-State district just west of the Mississippi. With the bill shelved, zinc producers will have to raise prices to survive. Slab zinc, 12¢ as this is written, is expected to go to at least 14¢.

PLASTIC PRICE CHANGES—In these days of rising prices of engineering materials, reductions are a novelty. Dow recently reduced prices on magnesium extrusions for truck body units an average of 28%. Reichhold Chemicals, Inc. has reduced alkyd resins by 10%, the fourth price reduction by that company, illustrating that as mass production advances on a comparatively new material, prices drop. On the other hand, Plexiglas was raised 7% July 1, after a series of steadily declining prices. Rises in raw materials were responsible.

JAPAN SHIPS US SCRAP—In view of the famine in steel scrap it is important to learn that 3,500,000 tons of ferrous scrap in Japan is available for shipment to the United States.



Elimination of Steel Basing Point System Would Have Varying Effect on Consuming Industries

by **HAROLD A. KNIGHT**, News Editor, Materials & Methods

THE FEDERAL TRADE COMMISSION is now actively investigating the steel industry to ascertain whether the multiple basing point system of selling steel, with its 80 basing points, violates the Federal Trade Commission Act of March, 1938 and the Clayton (anti-trust) Act. In April of this year the Supreme Court upheld a decision of the Federal Trade Commission that the multiple basing point system of the cement industry is illegal and issued a cease and desist order.

In view of what has happened to the cement industry, there is a strong probability that history will repeat itself as to the steel industry, which might easily result in some profound changes involving all those who buy and consume steel. Instead of the multiple basing point plan which involves selling steel to a consumer, delivered to the consumer's plant, with all competing steel makers quoting the same delivered price (which the F.T.C. calls collusion), the F.T.C. would compel all steel makers to quote steel and sell, f.o.b. their own mill, which, because of different freights for different distances, would result usually in no two identical prices quoted the consumer.

Steel supplies, as well as prices, could be disrupted if the Government succeeds in outlawing the long-established basing point pricing system now used.

Such a new f.o.b. mill system would result in the following major changes, it is contended: (1) steel makers would build plants in markets remote from present plants; (2) many steel consumers would move their plants closer to steel mills; (3) steel business would be more localized and steel makers would have monopolies in their own districts; (4) cross-hauling of steel (sometimes called "carrying coals to Newcastle") would be eliminated, thus lessening an economic waste; (5) the alleged evils of "freight absorption" and "phantom freights" would be eliminated; (6) steel makers' plants would be better scattered and diversified over the country, which would be good for both peace and war (however, if consumers moved into the backyards of steel producers this diversification would be offset); (7) more steel warehouses, both private and steel company-owned, will spring up throughout the country.

Some of the above points are bitterly disputed between the Federal Trade Commission and the steel makers. One of the queer phases in the matter is the absence of complaints on the part of consumers, the very ones the F.T.C. asserts it is trying to protect.

A questionnaire sent by MATERIALS & METHODS to consumers in many lines resulted in almost unanimous support of the present multiple basing point system. Neither have any definite complaints been unearthed in the arguments advanced before the courts.

In this connection Lynn C. Paulson, assistant chief trial counsel, writing exclusively to MATERIALS & METHODS, said: "I have noticed that consumers of steel are not vociferous in the denunciations of the basing point system. This strikes me as being somewhat phenomenal. It indicates to me a tendency and inclination on the part of consumers to bear the ills they have rather than fly to others that they know not of! It does not appear to be a well-reasoned position. Certainly the elimination of the basing point system in the steel industry will have a tendency to increase the volume of competition between the producers of steel, the consumers to be the immediate beneficiaries." That this lack of complaint somewhat preys on Mr. Paulson is indicated by the fact that he goes back to the subject: "It seems that consumers of steel and other commodities which have been sold on a basing point method are living in fear that if the system is outlawed they will find it more difficult to get materials than is already the case. The opposite should be true."

Fundamentals of Present Pricing

It is well to go into the principles of the basing point here. In an accompanying illustration is plotted the natural movement of steel bars into the Detroit automobile manufacturing district. Cleveland, Pittsburgh, Chicago and Sparrow's Point are all well recognized basing points. We'll assume a non-basing point mill is located, say only 30 miles away from Detroit. (However, the number of non-basing point mills in the United States is negligible.)

Cleveland, being the nearest basing point mill, sets the pace. Its basing point price on bars is $58 per ton, to which is added rail freight of $6.24 per ton, making the delivered price $64.24 per ton. (For simplification, we'll omit switching charges). This sets the price for all others who wish Detroit's business. If a Pittsburgh mill wishes a share, it will sell at $64.24, delivered too, and, because of a freight of $8.40, will realize a net mill price of $55.84. Chicago, with slightly lower freight than Pittsburgh, realizes a slightly higher net of $56.08. Sparrows Point, with $12 freight, has a net mill price of only $52.24, which might even be below cost of manufacture, but we'll assume the mill lacks orders and wants to keep men employed and organization intact.

The difference in freight between the Cleveland freight and the other freights in this example is "freight absorption." Thus, Cleveland absorbs no freight, but Chicago mills absorb $1.92 in freight; Pittsburgh, $2.16; Sparrows Point, $5.76. Assume, however, that Cleveland ships to Detroit by water at a rate of only $4.00 per ton. The price will still be $64.24, delivered, hence the net to the mill will actually be $60.24 instead of $58. This extra cash at mill is called by the F.T.C. "phantom freight," or freight which the mill did not pay, but for which the consumer is charged for, though never paid by anyone.

Consulting the map, consider the non-basing point mill, with only a $2.00 rail freight. It still sells at the delivered price of $64.24, making a net at the mill of $64.24, the highest of them all. The non-basing point mill might well be called a parasite. Again, the F.T.C. calls this "phantom freight."

History of Basing

An interesting question that will come to the reader is: "How did the basing point system spring up? Did some master mind, such as Judge Elbert Gary, think it up, say when the U.S. Steel Corp. was formed in 1901, or did it naturally evolve?" The usual answer from authorities is that it evolved.

During the "Pittsburgh Plus" case the trial examiner found that prices were quoted f.o.b. mill until the P.P. basing point practice began in the 1890's. Around 1750 iron products were sold on a Philadelphia base, with outlying mills absorbing freight to bring their products to a central market in competition with nearer mills (the same as today). The Pittsburgh Plus system was abandoned in 1924 by a cease and desist order. This single basing point system was succeeded by the present multiple system.

Chicago was one of the early basing points. According to an N.R.A. report in 1934: "In the growth of the Chicago district's productive capacity we find early signs of the natural basing point development when capacity in a district increases to the point where it begins to require all its own market and to press for more. Then it breaks away from the 'mother' basing point, stands on its own feet and quotes its own base prices, which are lower than prices delivered from distant producing points."

A few mills are not members of the basing point set-up. Thus, Lukens Steel Co. has been selling f.o.b. mill for five years. The Pacific Coast Steel Co. and others quote f.o.b. mill, with apparently no pressure placed on them to join the multiple basing point system. It is quite possible that in view of the activity of the F.T.C. in prosecuting the steel industry a stampede to go on an f.o.b. mill basis may take place. Even as this article is being read the f.o.b. mills may be legion.

There are scores of other industries that still observe, or did, the same or equivalent (such as zoning, used by the lead products industries) systems. Besides cement, there are lumber, glass containers, builders' supplies, farm equipment, ice, road machinery, paint and varnish, business furniture, liquifying gas, auto parts, ladders, paper and pulp, structural clay, china and porcelain, reinforcing materials, vitrified clay, anti-friction bearings, some foods and groceries, lye, wholesale coal, milk cans—even cigarettes.

The main objection of the Federal Trade Commission to multiple basing in steel is this. Consulting the map again, a Pittsburgh steel mill charges a base price of $58 at mill, which is the same to all customers within the normal district, but when it sells outside its own district, it accepts a less price, $55.84 when sold to Detroit. Thus, in the eyes of the F.T.C. this is illegal price discrimination and against the local consumers.

Since civilian steel consumers have apparently not complained of the basing point system, one suspects that Governmental agencies themselves have com-

plained of the uniform delivered prices submitted by several bidders. Usually regulations for Governmental purchases call for awards to lowest responsible bidders. When prices are uniform, they merely pull numbers out of a hat. Perhaps the most extreme case of uniformity was cited by the F.T.C. in the cement case. Here 11 producers quoted a price in dollars, uniform to seven decimal points, or $3.2865854. Steel makers, too, have quoted uniformly to the Government, contending that Government bids are always made public and that it would demoralize steel markets if civilians discovered any cutting of prices. However, U.S. Steel once answered in a former basing point case that price cutting is frequent in normal times, even to the Government. Thus, through 1938 and the first quarter of 1939 steel sold to the Government totaled $10,550,000, of which 80% went to the lowest bidder. Only 10½% went by lot because of identical bids. They concluded that the basing point system *per se* is not the cause of identical bids.

Will Mills Move to the Markets?

Earlier in this article there were presented seven possibilities of radical changes among steel producers and consumers if multiple basing is abandoned. First, many companies will move old plants or build new plants closer to markets. Thus, a steel maker who replied to our questionnaire stated: "New and probably unnecessary steel plants would have to be built in various places, particularly Eastern seaboard, Detroit and Chicago."

The *New York Times* came out with an exclusive "story" on May 23 to the effect that more than $100,000,000 may be spent soon to build the East's first 350,000-ton steel mill in the Greater New York area. The article recalled that this is the first attempt to make New York a steel producing center since 1906 when prospects for a mill on Staten Island were ended by the financial panic of 1907. Most raw materials could be shipped in by water, the same as now to Delaware River points, Sparrows Point, Md., etc. The marked development of Adirondack ores in recent years would mean a source with moderate rail freights. New Jersey and New England are important steel consumers. It is suggested that a second seaboard plant might well be built at Bridgeport, Conn. H. A. Brassert & Co., steel mill consulting engineers, already have plans drawn up for the New York project.

At present, among large steel producers, Bethlehem Steel Co. at its Bethlehem, Pa., plant is the logical basing point to serve New York, with a freight rate of $5.20 per ton, with Bethlehem's Sparrows Point, Md., second in line with $7.60 per ton freight, while Carnegie-Illinois and Jones & Laughlin, both of Pittsburgh, are handicapped by $11.20 per ton. Assuming that $58 per ton, Bethlehem, Pa., is the base price on steel bars, the delivered New York price is $63.20, which Sparrows Point and Pittsburgh must meet, in both cases "absorbing" freight.

When switching charges and other factors are figured in, New York consumers might save as much as $15 per ton by having a local steel mill, at least theoretically. However, opponents of the F.T.C. state that a multiple basing cease and desist order would mean breaking up of large steel producing units, now located at best sources of raw materials, and scattering as smaller units among consuming districts. This, they claim, would raise steel prices considerably. Moreover, construction of new plants at today's price would cost $300 per ton of steel produced as against $56 in pre-war. It would require much scarce steel to build the plants.

Steel makers with lowest costs of manufacture are usually located on waterways where, perhaps, the bulk of raw materials is shipped into the plant by water and a large share of finished steel shipped to markets, the same way. Wishing to delve into the rail freight rate situation, as it applies to steel makers not located on waterways, we asked the Interstate Commerce Commission to furnish us with some facts. Thus, on a 100-mile haul freight rates on manufactured iron and steel articles are $3.20 per ton. Rates on scrap iron are $2.20; on petroleum for fuel, $5.60; and on ground limestone, $1.46.

An official of the I.C.C. states that the rates on the different commodities vary in amounts for equal distances and that the variations do not follow any set pattern or relation between the different commodities. The value of the service, value of the commodity, volume of movement, transportation and loading characteristics, revenue needs of a carrier, system or group of carriers, competition between carriers, market competition and many other factors are taken into consideration by the carriers in determining the measure of a single rate between point of origin and destination, or in determining the level of a general commodity rate adjustment.

The same official concludes that it is doubtful that the situation would be changed to any marked degree by shifting the location of the plant (assuming always that railroads are sole means of transportation on incoming and outgoing shipments) since, as the distances over which the raw materials must be drawn are increased, the rates on those materials also increase and often in direct proportion to the decrease in the rates on the finished articles. Either way you go, one set of rates goes up while the other goes down, so it doesn't have a great deal of effect in the final result.

It is questionable whether due consideration has been taken of the fact that incoming materials represent four times the tonnage of outgoing finished articles.

Consumers Move Near Steel Mills

Even before the present campaign of the Federal Trade Commission, many steel makers had been refusing to sell far afield because of constantly rising freight rates and plentifulness of demand at home. Consumers at St. Louis, for instance, have complained bitterly that old-time suppliers at Pittsburgh and elsewhere have abandoned them and left them prey to gray marketeers.

To what extent consumers would move to the "backyards" of steel makers is problematical. It would depend a great deal on to what extent steel makers move plants closer to markets. Thus, where consumers are already densely concentrated, as in Detroit, the steel makers would move to the consumers. In some

cases the "mountain would move to Mahomet;" in other cases, vice versa.

In recent years bombing of our industrial centers by an enemy has been very much on the minds of those who plan the country's defense. Lynn C. Paulson, assistant chief trial counsel for the F.T.C., writes us: "The more basing points there are, the greater the dispersion of consuming industries. Hence, the elimination of the multiple basing point system may be looked to as a stimulant in the direction of greater decentralization of industry using heavy goods as raw materials."

However, there are those who will dispute this. They point out that there will be more concentration, with consumers moving close to supplying plants, like a sow with a litter of suckling pigs. Yet it must be admitted that no group of plants would be as vital as the present concentration at Pittsburgh, the Delaware River, and Connecticut Valley.

Virtually all concede that steel business would be more localized, particularly on so-called "commodity" (common items) steel; consumers might still have to go long distances to secure specialties, such as bale ties, clad steel, and special analysis items. Those defending the present system maintain, however, that steel prices would be generally higher: (1) because steel mills would be smaller and costs higher; (2) because makers would be local czars and monopolists and would tend to charge "what the traffic will bear."

One charge of the F.T.C. is that under the present system there is too much cross-hauling, which is an economic waste, despite the fact that it gives added revenues to the railroads. A perfect example of a cross-haul would be a steel shipment from Pittsburgh to the Bethlehem, Pa., district, passing on a two-track railroad a like steel shipment from Bethlehem to the Pittsburgh area at the half-way mark.

The defenders of the present system claim that there would be just as much cross-hauling under an f.o.b. mill plan. The claim that more steel warehouses would spring up at sites strategic to markets throughout the country and the cross-hauls would take place on shipments of steel from mills to warehouses.

Virtually all factions concede that fictitious freights would be eliminated and that real freights would be paid in exact amounts by consumers. Moreover, water and truck shipments would be stimulated greatly. The chief drawback of water shipment is that for economy greater lots of steel must be ordered at one time; secondly, delivery is slow, hence the consumer would have to anticipate needs longer in advance. Again, the greater exposure to dampness might call for more elaborate rust-proofing of steel in transit.

In replying to our questionnaire to steel consumers, a Mid-Western user of flat-rolled products stated: "We expect to move more steel by river inasmuch as river rates have been for years cheaper than rail rates. As for sending our trucks to any steel mill to pick up material, we believe that there is a sufficient number of trucking companies now who have specialized in this type of work."

Other Possibilities

About 19% of steel tonnage sold in 1946 was from warehouses. These jobbers charge not $10 to $20, but $30 to $50 per ton above mill prices, hence purchasing out of warehouse is not the most economical. Steel men predict that under an f.o.b. mill system more warehouses, both company-owned, such as Joseph T. Ryerson & Sons Co., (Inland Steel) and private, would spring up over the country. Thus, Carnegie-Illinois, already with a warehouse in northern New Jersey, might enlarge this and probably build other warehouses at likely locations on the Eastern seaboard. Presumably, they would continue to quote full jobbers' prices, thus adding to the over-all sales prices of steel.

Besides the seven main probable developments there are two additional possibilities in case a cease and desist order is made to apply to steel. First, certain steel makers may buy outright some of their chief customers and run them as subsidiary companies. They would merely "transfer" steel to their fabricating subsidiary, with no prices showing on books until the final end product is sold. This would have the effect of making big business even bigger and would bring about conditions opposite from what Washington has in mind as ideal. Steel makers have already been criticized for this very thing, such as making steel barrels instead of being willing to stop with the manufacture of sheet steel.

Secondly, steel trade associations may have to disband to avoid the appearance of evil, say in the form of seemingly arranging price fixing and other uniform practices. Imagine, for instance, the venerable American Iron & Steel Institute being forced to disband. Thus, Lynn C. Paulson of the F.T.C. has been quoted as saying that freight rate compilations of the Steel Institute are, in effect, price books. Lowell B. Mason, another member of the F.T.C., speaking at the Harvard School of Business Administration, stated recently that if the laws continue as they are now trade associations are doomed.

Conclusion

Relatively stable prices, by contrast with those of agricultural products, are characteristic of durable goods industries and result naturally from relatively inflexible costs, proportionately high overhead costs, inelasticity of demand, and other factors. The location of mills on the sole basis of nearness to a market would always subject them to local and seasonal variations in demand and would be disastrous if the market should move away because of labor difficulties or other causes. There is no reason to suppose that a uniform f.o.b. mill price system would do away with any price leadership which may exist today.

The F.T.C. objects to price discrimination. Thus, Pittsburgh makes more steel than it can normally consume. It therefore needs to ship outside of its district to dispose of its surplus. Under the present system it sells outside at a lower f.o.b. mill price equivalent than when it sells locally—"discrimination."

However, assume that Pittsburgh is selling this surplus outside the country in normal times, such as during pre-war. Again it has to make a sharp price concession to compete in foreign markets with foreign steel makers—"discrimination," again—but the Government this time calls it legal.

Seamless steel tubing being heated by induction to 2350 F for upsetting. (Courtesy: Ohio Crankshaft Co.)

Heating Metals

by Induction and High-Speed Gas Methods

by **H. R. CLAUSER**, Associate Editor, Materials & Methods

THE CURRENT DEMAND, which started before the war, for high-speed metal heating methods and the growing trend to fit heat treating directly into the production line has resulted in the rapid development and expansion of two relatively new heating methods. These are high frequency induction heating and high-speed direct gas heating. These two heating processes are competitive in a number of metal heating applications. But at the same time, where applicable, both share many of the same advantages over older conventional furnace heating methods. Some of these include higher rates of heating, thereby increasing rates of production; ability to control heating pattern and depth of heat penetration; elimination of scaling, decarburization, and distortion; and conservation of floor space.

Induction and high-speed direct gas heating are competitive, but also share many of the same advantages over older, conventional furnace methods.

The question then naturally arises: in uses where high-speed heating is applicable, which method offers the most improvement over conventional heating furnaces? There is no simple answer. Each method has certain inherent capabilities and limitations; and these define their general range of usefulness. In selecting the proper heating method for a particular job, the inherent characteristics of both must be considered in the light of specific requirements. In this article, then, we will be mostly concerned with a comparison of these two high-speed heating methods in their common fields of application which are surface hardening, and through heating for forging, homogeneous heat treatment, and brazing. In addition, we will discuss the advantages they share over the older conventional heating methods.

High-speed heating methods are particularly suited to heat treating bar stock. Here bars are fed through an induction heating machine on a motorized conveyor. (Courtesy: Ohio Crankshaft Co.)

First let us see briefly how each of the heating methods works.

Induction heating might well be thought of as *induced* resistance heating. A high frequency current passing through a coil placed around the work piece induces a circulating current in the material. And it is the electrical resistance to the flow of this current in the material that results in the generation of heat.

The amount of heat and temperature that can be attained, and their relative distributions are only limited by the capacity of the induction unit and the mass and heat conductivity of the material. The temperatures possible may range up to the melting point of the metal being heated. An important characteristic of induction heating, which suits it to surface hardening, is that the generated heat is inherently concentrated on the surface of the conducting material. However, since electrical resistance increases with temperature, as the surface temperature rises, the current seeks the layers beneath which have lower resistance. This fact, in addition to the heat transferred by conduction, makes possible through hardening of metals.

The high-speed direct gas heating method uses ceramic type gas burners. With these burners a compacted, intimate gas and air mixture enters and burns at a high rate in the confined space of the ceramic combustion chamber. The ceramic is heated to incandescence and raises the temperature of the combustion gases. The heat of combustion is transferred directly from the burner to the work by convection and/or radiation, depending upon the design.

Through the use of these burners higher temperatures of combustion products and higher rates of heat transfer are obtained than is possible with conventional burners. Flame temperatures achieved in high-speed direct gas heating approach closely the theoretical combustion temperature of gas in air. In one design of burner the products of combustion are discharged at a temperature of about 3000 F and at the rate of 1400 ft. per sec.

As in induction heating, the high heating rates with ceramic burners result in a considerable thermal gradient between the surface and the interior of the stock being heated. Where through-heating is required, an equalization period is needed to allow the heat to penetrate uniformly through the cross section. However, the rate of heat input is so rapid that soaking time is reduced to relatively short periods. The rate of heat input in both induction and high-speed gas heating must, of course, be controlled so that surface temperatures do not become excessive and cause burning or grain coarsening. But the fact that the work can be heated one unit at a time makes possible simple, accurate control by which excessive surface temperatures are avoided.

Surface Hardening

The operation of surface hardening by induction or high-speed direct gas heating briefly consists of heating the surface up to above the hardening temperature very rapidly and then immediately quenching to get the desired hardness.

High-speed heating has brought about some revolutionary changes in methods for hardening steel sur-

faces. Perhaps the most important is the introduction of the concept of getting a hardened surface without changing the chemical composition of the surface layer. Before this, parts requiring a hard surface and a relatively soft, ductile core were made of low-carbon or alloy steel and carburized. In such cases it is often necessary to use alloy steels solely to avoid the distortion often caused when carbon steel is water quenched after the carburizing treatment.

Surface hardening by high-speed heating methods largely eliminates distortion and is, in general, a cheaper method largely due to the higher production rates possible, and the mechanical and automatic handling of the stock. Additional savings are realized where medium carbon steels can be substituted for alloy steels formerly required.

As far as the metallurgical quality is concerned, there is no essential difference between the quality of the hardened surface layer obtained by the two high-speed methods. They do differ, however, in the minimum depths of the hardened zone possible. Induction heating theoretically permits unlimited control of the depth of hardening. In actual practice the depth is always greater than the theoretical. Other factors being equal, the depth of hardening is a function of the frequency of current used. The minimum depth of hardened case generally obtainable in practice is about 0.010 to 0.015 in. Average case depths with induction heating run around 0.040 to 0.060 in.

With high-speed gas heating it is practically impossible to get a hardened surface layer less than 0.125 in. Smaller hardened depths are not possible because at present the rate of heat input (considering a maximum possible temperature of 3000 F) is not fast enough to maintain the necessary thermal gradient between sections thinner than this and the core.

While induction heating is most suitable for surface hardening parts with regular shapes, having uniform cross section throughout, it can also be adapted to some irregular shapes. With generally used frequencies the current follows within certain limits the contour of the part quite closely. There are many parts, such as large sprockets, on which formed inductors can be used. In other applications it is necessary to harden various portions of the part separately. This is done in the case of large sprockets or gears where one tooth at a time is processed.

Internal surfaces such as cylinder liners and tubing can also be handled by induction methods by using special inductor coils that fit inside the work piece. Parts from 1 to 15 in. in dia. have been processed in this fashion. For hardening internal surfaces, the wall thickness should be at least twice the depth of the hardened layer.

Although high-speed gas heating is not applicable to the hardening of internal surfaces, it is quite suitable for irregular shapes and varying cross-sections. The ceramic burners can be arranged and spaced to conform to the geometry and variations in mass of the object. For example, in hardening the teeth of automotive starter ring gears, burners are made into appropriate circular shape to heat all teeth at the same time. Another example is selective hardening of plier jaws in which the orifice of a nozzle type burner is shaped to the desired hardening contour.

Where none of the characteristics just discussed is a controlling factor, the selection may revolve about economic considerations. In general, based on the figures in a report prepared for the American Gas Association by Battelle Memorial Institute, the capital cost of a high-speed direct gas heating installation for a given rate of production is less than that for an induction heating installation. The report cites the cost of a 150-kw. induction heating unit as typical. The cost of the power plant is given as $13,000 plus about the same amount for auxiliary equipment, to make a total of $25,000. Direct heating gas equipment of the same capacity is reported as costing from $12,000 to $20,000.

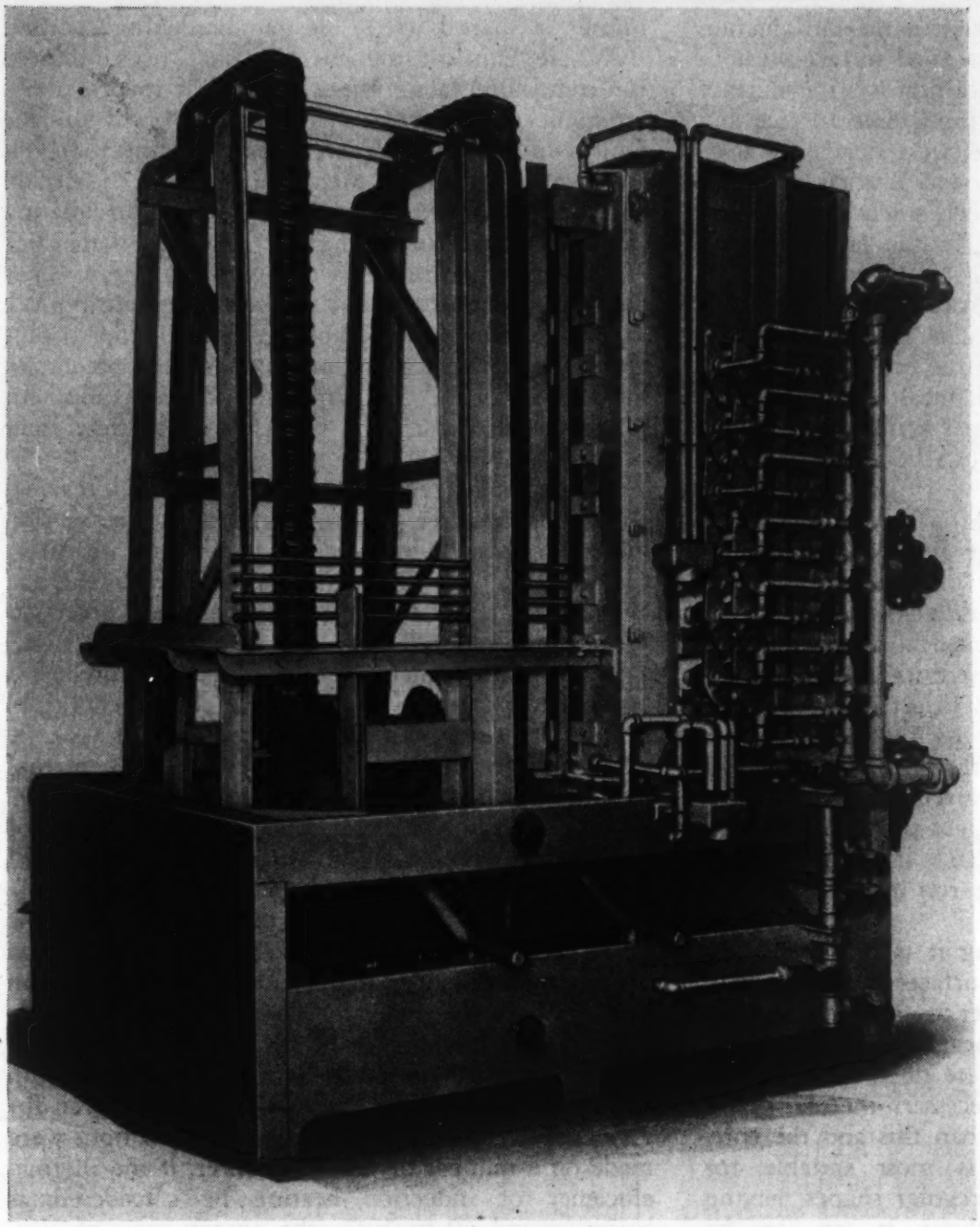
In this same report the cost of "useful thermal energy" to surface harden with induction heating methods is also found to be higher than with direct gas heating. The figures are based on a thermal efficiency of 10% for both induction and direct gas heating, and the following costs of energy: electricity, 1.5¢ per kw.-hr.; natural and/or manufactured gas, 50¢ per M cu. ft. On this basis the cost of energy to surface harden 2-in. dia. bars to a depth of 0.12 in. would be as follows: electricity, $4.50 per ton; manufactured gas, $1.03 per ton; natural gas, 56¢ per ton. The report, however, points out that labor costs favor induction heating slightly because a higher type of operator is required for direct heating equipment.

In arriving at the energy cost cited above, the figure of 10% for the thermal efficiency of induction heating might be open to question since the induction heating industry generally considers the efficiency for surface hardening to be up around 40 to 50%. This figure of 10% used by Battelle was calculated on the basis of the "useful thermal energy" required for given depths of hardened zone. Such calculations were made on a number of parts. However, if the thermal efficiency of induction heating be considered as being around 40 to 50%, the energy costs of electricity and manufactured gas per ton of steel become about equal. A manufacturer of induction heating equipment, in commenting on the Battelle report, asserted that the electrical energy used for surface hardening was a small fraction of the total processing cost. He also said that thermal efficiency for surface hardening must take into consideration the power density used, since when this value increases, heating time decreases and radial energy losses are less.

Therefore, it should be pointed out here that while these cost figures serve as a typical example, they should not necessarily be taken as final. Cost considerations are always complex and involve factors that cannot receive accurate attention in general examples. The cost of electricity and gas, for example, varies considerably in various parts of the country, and this along with other circumstances may, in particular cases, offer a different cost picture to the one presented here.

Forging

There can no longer be any doubt that in production forging and similar forming operations high-



This bar-end high-speed gas heating equipment heats 7 in. of the end of steel bars, ½ to 1½ in. in dia., to 2250 F. (Courtesy: Selas Corp. of America.)

speed heating of the stock offers many important advantages over the older fuel-fired furnace method. A primary advantage of both induction and direct gas heating is the very rapid heating it affords. Conventional forging furnaces are limited to a temperature no higher than that to which the part will be brought for forming, and this means a long heat-up period. The slow heating, in itself, is not always objectionable, but its effects usually are. Slow heating means longer heat exposure which, in turn, promotes scaling and decarburization. By rapid heating methods these objections are virtually eliminated. The elimination of scale increases die life, makes de-scaling operations unnecessary, and saves metal loss from scaling.

Another result of higher heating rates is saving in space. For the same capacity, high-speed heating equipment occupies from one-third to one-half the space required by conventional furnaces.

Finally, high-speed heating provides an automatic heating device which fits into the production line. It permits heating the stock in units. The heat is directed to each piece exactly where needed and the intensity and duration can be carefully controlled. These automatic features and close control permit the heated units to be delivered to the forming machines at the exact rate and temperature required.

While all of these advantages are shared by both induction and high-speed gas heating, there are some differences between the two that are worth noting. For a given mass of metal the heating cycle with induction heating is faster than with high-speed direct gas heating. This higher heating rate for induction heating may or may not result in a smaller amount of scaling and decarburization, depending upon the application and the heating times involved. However, it can make a difference in space requirements. To obtain a capacity with high-speed gas heating equal to that of a given induction unit, larger gas heating units are usually required.

On the other hand, for the same capacity, the capital cost of high-speed gas heating equipment is generally considered less than that for induction heat-

ing units. The Battelle report cites two examples where the capital outlay for the induction installation was about 60% greater than that for gas heating equipment. The cost of useful thermal energy in high-speed gas heating is also reported to be lower.

As in surface hardening, induction heating is limited to parts having fairly regular shapes and cross sections to which inductor coils can conform. Where large differences in cross section are involved, it is often difficult to heat the entire part uniformly. However, where only a certain portion of an intricately shaped part is to be heated, this limitation of induction heating does not necessarily apply.

High-speed gas heating equipment can accommodate a range of shapes and cross-sections by proper arrangement of the heating pattern. It is also quite flexible in being able to handle a variety of shapes and sizes without changing a given pattern of burners.

The heat dissipated to the surrounding working area is considerably greater with high-speed gas heating installations than with induction heating units. From the standpoint of working conditions this may or may not be considered a disadvantage of high-speed gas heating, depending upon the particular circumstances.

Heat Treating

The use of rapid heating methods for through-heating of steel for heat treating operations such as hardening, annealing and normalizing is still small and not as important as it is in surface hardening and forging. Conventional furnace methods still offer a number of advantages over the newer rapid heating methods. Conventional heating furnaces are more versatile and can handle parts regardless of size, weight and shape, within the limits of the particular design. They can process large, heavy parts, while high-speed heating in comparison is limited to relatively small and regularly shaped products. They also can be provided with carefully controlled atmospheres where necessary. And in most cases, except under certain favorable conditions, they are the more economical method of heating for homogeneous heat treatment.

There are, however, certain types of heat treating applications where high-speed heating fits in well. For example, in the continuous heat treating of bar stock and tubes. The stock can be passed continuously through the high-speed heating unit and be heated to the hardening temperature, quenched, and then reheated to the drawing temperature. Such installations are designed for handling specific products and fit right into the production line. They usually require less space than do conventional furnaces.

Another suitable application is selective heat treatment. Because of its ability to provide concentrated heat patterns, certain portions of parts can be selectively hardened or annealed, leaving the rest of the part unaffected.

Since high-speed heating has had limited application in the through heat treatment of steel, there is not much basis for comparison of induction and high-speed direct gas heating in this particular field. Where they have been applied, the quality of the heat treated part has been equally satisfactory.

Brazing

To avoid oxidation in brazing operations, the parts and/or the brazing alloy must be either fluxed, or heated in an atmosphere, or brought up to brazing temperature rapidly enough to avoid oxidation. High-speed heating methods meet the requirement of being able to rapidly heat parts up to temperature. Since there is no direct impingment of flame on the joint, the flow and contour of the brazing alloy can be carefully controlled. Also, the heat can be localized, which is an advantage when brazing parts with portions that might be injured by heat.

Induction and high-speed gas heating have given satisfactory performance in a variety of brazing applications, both from the standpoint of quality and economy. Induction heating in particular is used for countless applications; it is estimated that brazing and soldering is the largest single application of induction heating. Both methods can be used in either automatic or semiautomatic equipment to attain very high production rates.

Brazing by high-speed direct gas heating is still relatively new. In general, its capabilities and advantages run similar to those of induction heating. However, the gas method can be adapted to fairly large and intricate objects, which would not be practical to do by induction heating methods.

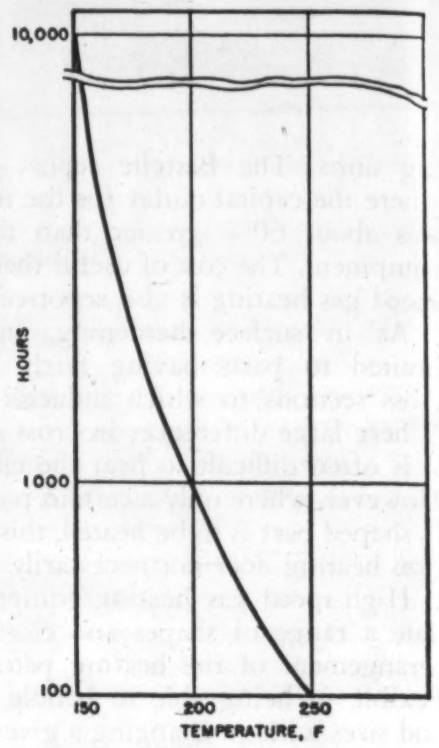
References

S. L. Case, L. R. Jackson & R. J. Lund. "Induction Heating in Relation to Industrial Gas Heating." Report by Battelle Memorial Institute for American Gas Assn.

H. B. Osborn, Jr. "Induction Heating," published by The Ohio Crankshaft Co. "Speed Heating of Metals by the Gradiation Process," published by Selas Corp. of America.

An example of the application of high-speed direct gas heating for brazing a flange to a tube. (Courtesy: Selas Corp. of America.)

NEW MATERIALS PREVIEW



Conductive rubber, which has a comparatively short life at its maximum temperature, has a long expectancy when heated to 150 F.

Electrically-Conductive Rubber

RUBBER, DURING MOST OF ITS LIFETIME as an engineering material, has had as one of its outstanding characteristics its insulating properties against the passage of electrical current. Now, however, there is available a rubber which does conduct electricity and can serve as a resistance heating element or to dissipate static electricity.

Conductive rubber is a development of the U. S. Rubber Co., which set out a few years ago to produce a material that would conduct static electricity away from automobile tires. Early materials and their applications were only moderately successful. One well-known application was the edging of aircraft propeller blades to prevent ice formation.

Now the material is being improved and applications found which give promise of making conductive rubber an important material for a variety of uses. At present the greatest use of the material is for radiant heating panels in residential construction.

A new type of rubber, which has many potential uses, can supply heat in the range of 100 to 150 F.

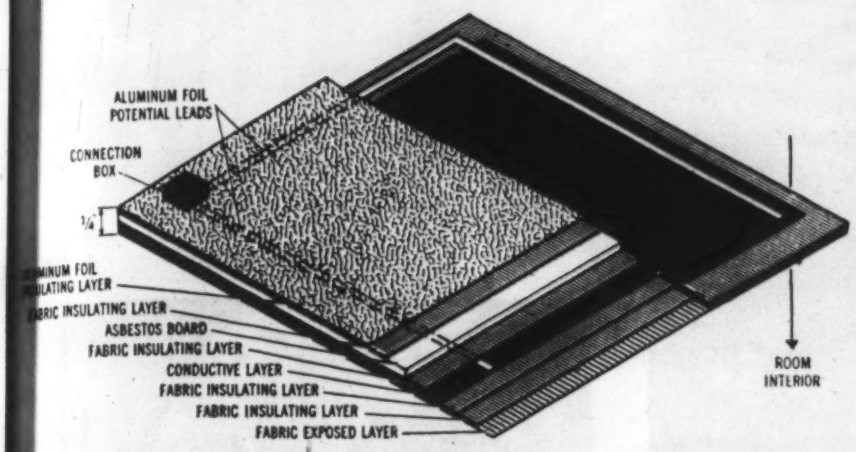
Conductive rubber is capable of furnishing heat in the range between 100 and 150 F. This rubber has reasonably long life at the lower temperature limits, but life is reduced in direct relationship to the higher operating temperatures.

The key material in conductive rubber is an acetylene carbon which is thoroughly diffused throughout the rubber. Assisting the flow of rubber are embedded strips of aluminum foil.

Although its use in home heating is foreign to possible industrial applications, the methods of application will illustrate many features of conductive rubber. As now used, the material is supplied in panels approximately ¼-in. thick, built up as follows: An exposed layer of plain cotton sheeting, which anchors surface decoration; two insulating layers of phenolic resin-impregnated cotton sheeting; conductive rubber-impregnated cotton sheeting; insulating layer of phenolic resin-impregnated cotton sheeting; backing layer of 3/16-in. asbestos board; backing layer of resin-impregnated cotton sheeting and a 0.001-in. heat insulating layer of aluminum foil.

The bonded assembly looks much like standard interior wall board. The panels operate on 220-v. current and are supplied in two standard wattage densities: 17 and 22 watts per sq. ft. Heat output is 58 and 75 Btu.'s, respectively. Power consumption of 4 by 4 ft. panels is 272 watts for the 17-watt panel and 352 watts for the 22-watt assembly. The 220-v. operating voltage is used because of many economies.

The total connected load to heat an average five-



In this schematic drawing can be seen the manner in which electrically conductive panels are built up for space heating.

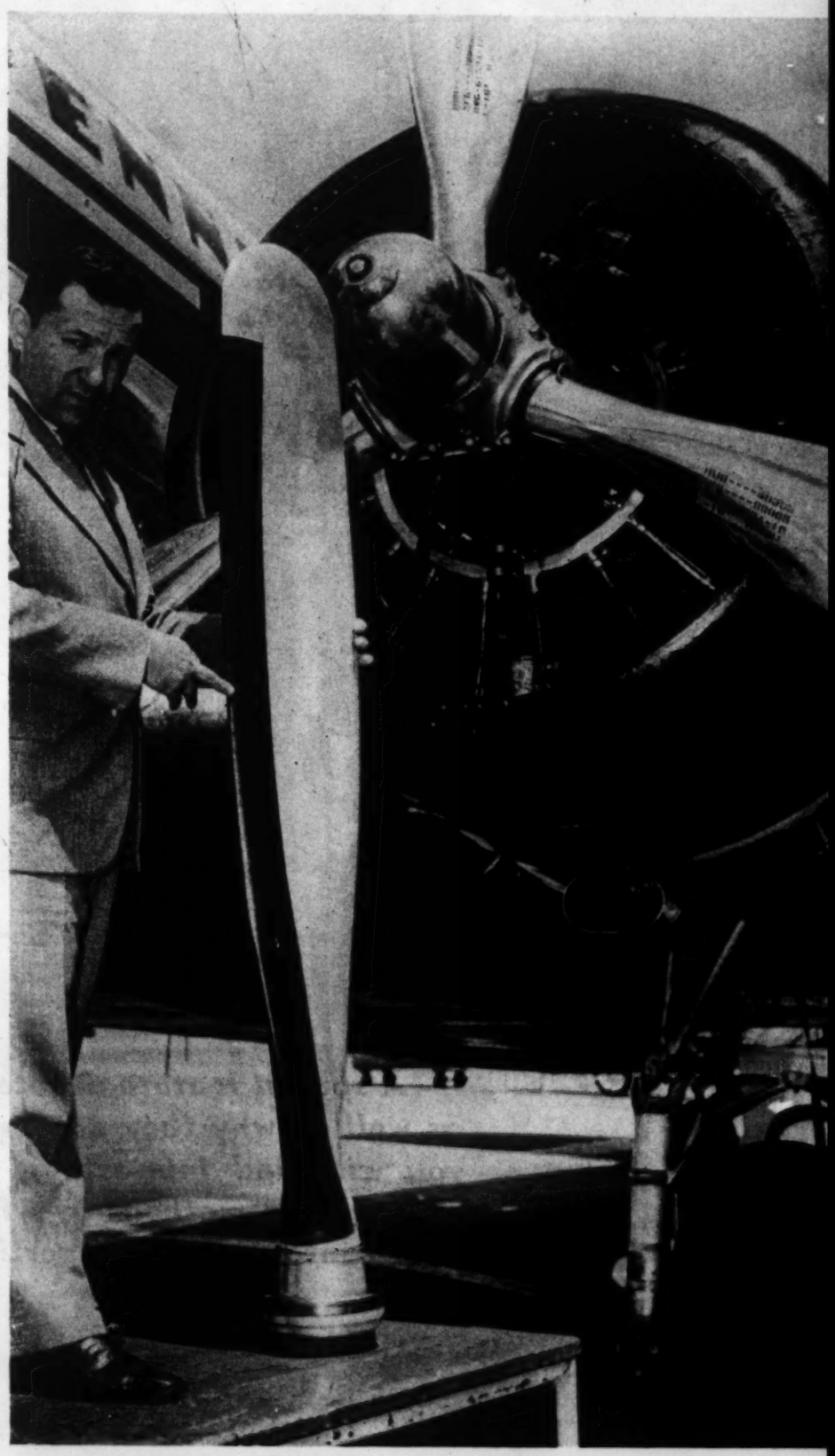
Conductive rubber is used in chicken brooders to supply a steady even heat for the baby chicks.

room house would approximate 10 kilowatts (equivalent to the connected load for 1½ electric cooking ranges). Total current carried by any one of the five circuits will not exceed 20 amp. The use of conductive rubber for home heating purposes is said to be economical at electric rates of 1½c per kilowatt-hour, or less.

For heating purposes, several applications appear as likely possibilities. For instance, pipes carrying liquids, which must be maintained at constant temperatures, could be wrapped with conductive rubber sheathing; drying rooms for foundry sands could be finished with panels of the new material; areas subjected to forced ventilation could be warmed by this method; various heating and drying operations could utilize the available temperature ranges (as, for instance, bonding and forming plywood).

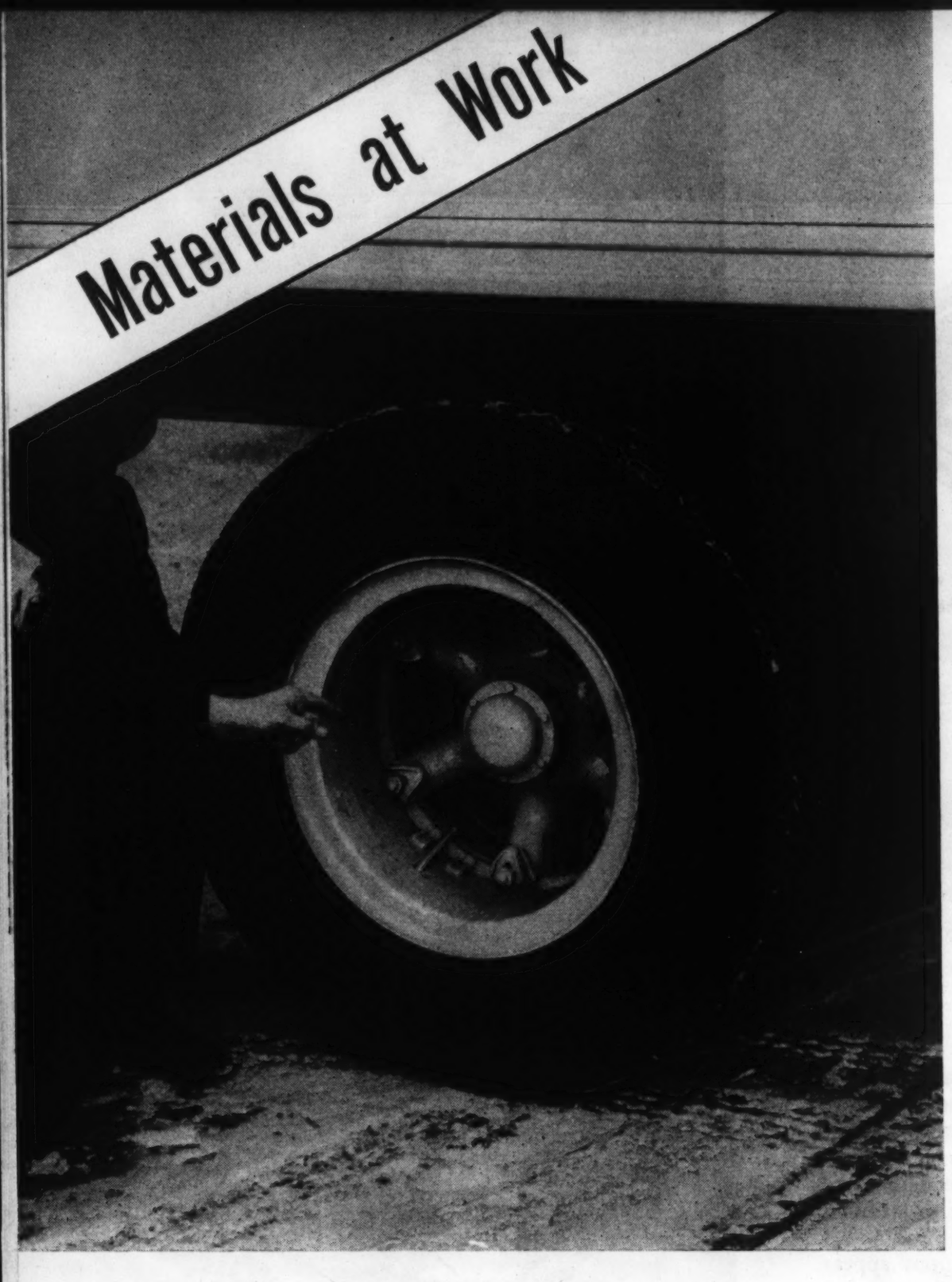
Conductive rubber has already found service as an eliminator of static electricity, such as in static-free brushes, floors, vats and other equipment of munitions plants and related activities. Printing presses might be an apt application, since static often makes paper hard to handle during printing.

One recent application as a heating element is in a gasoline dehydrator used in severe arctic climates. In such areas as Alaska it is frequently necessary to remove water which has found access to gasoline. Without application of heat the water would freeze and hamper the filtering operation. A large conductive rubber pad is wrapped around the dehydrator tank, and insulated to hold the heat in. The heating element maintains the gasoline at 50 F on the most frigid days.



The formation of ice on aircraft propeller blades is prevented by the use of conductive rubber along blade edges.

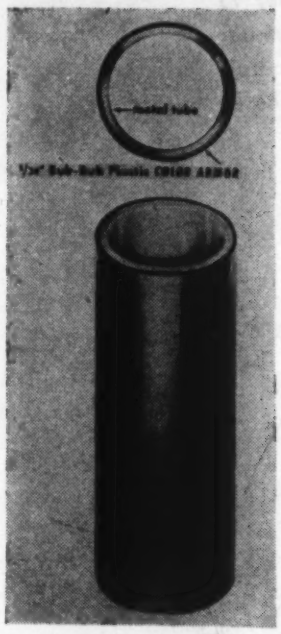
Materials at Work



CAST ALUMINUM TRAILER WHEELS

The Trailmobile Co. is using permanent mold aluminum castings for wheels on its huge transport trailers, with a weight saving of 220 lb. per trailer. Test bars from the wheels show a tensile strength of 40,000 psi. Careful control over the casting process results in uniformity from wheel to wheel and is said to eliminate shrink holes, surface porosity and weak spots. The castings are heat treated to attain the desired strength.

— A special feature devoted to showing how materials are used as well as why they are used in their newer applications. Here you will find interesting, informative items and illustrations showing the methods by which progressive engineers are taking advantage of the properties of materials—both new and old.

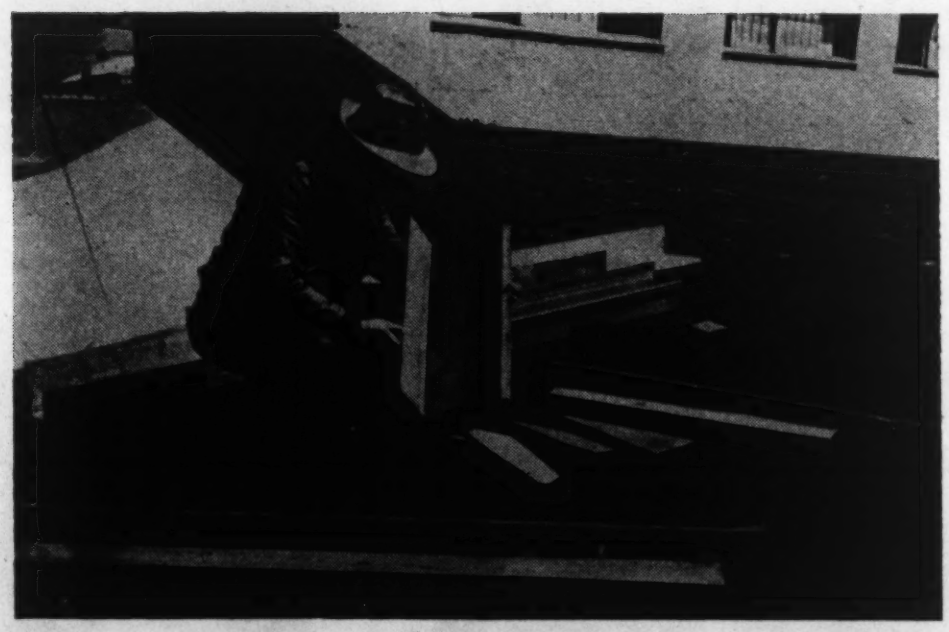


COLOR ARMORED TUBING

A new composite material known as Rub-Bub Color Armored Tubing is finding use as structural members for tubular frame furniture, fixtures, guard rails, seat grab rails in vehicles and for color-coded fluid lines in processing plants. Basically armored tubing is electric-welded steel tube covered with a 1/32-in. coating of colored plastic, put in place by an extrusion process. However, the same type armor can be deposited on any diameter steel, aluminum or magnesium tube. The material is easily cleaned and tough enough to resist violent shocks without cracking, and can be fabricated to any desired size and shape. Six standard colors are available: green, red, yellow, blue, brown and gray. Samuel Moore & Co., Mantua, Ohio, developed the material.

NYLON WHEEL BEARINGS

One of the newest uses of molded nylon is its adoption for wheel bearings in baby carriages. Nylon in this application is said to outwear metal and have the additional advantage of requiring no lubrication. In tests on the present application, the nylon bearings showed no wear under conditions which caused wear on the axle. The use of similar bearings in electrical equipment such as food mixers and shavers is now being investigated. The bearings used on these carriages are molded by Machinecraft, Inc., Whitman, Mass.

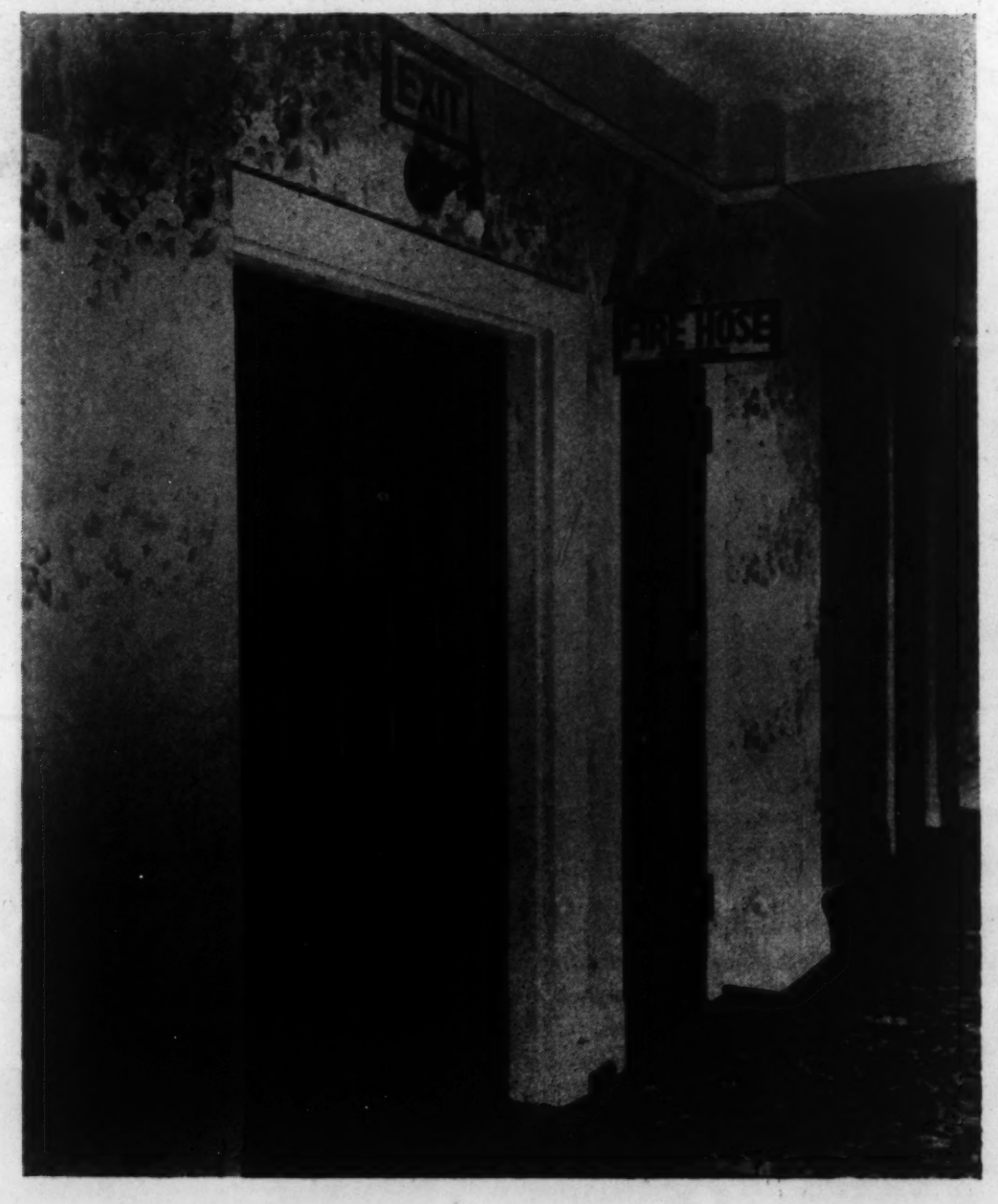


MONEL AS A ROOFING MATERIAL

Monel is now becoming a stronger contender for a leading position as a roofing material. A new type of Monel, specifically designed for the purpose by International Nickel Co., is expected to have a service life of over 100 years. The sheet is said to be softer in temper than previous Monel roofing sheet and thus more easily formed and soldered. In addition to being used for complete roofs, Monel is being used for such structural purposes as skylight framework, penthouse sidings, flashings, gutters, cornices and downspouts.

MAGNESIUM CARLOADING TUBES

Gasoline refineries and bulk storage plants are now using 3-in. dia. magnesium tubing for spouts in transferring gasoline into railroad tank cars. The tubes are sufficiently long to reach to the bottom of a standard tank car so the gasoline can be conveyed to the car bottom without splashing. A nipple is welded to one end of the tube and the end threaded for screwing into the loading hose. The lightweight construction is used because it is nonsparking, easier to handle and lower in cost than were similar spouts of the same size in heavier metals like copper, brass or galvanized iron, chosen for their nonsparking qualities.

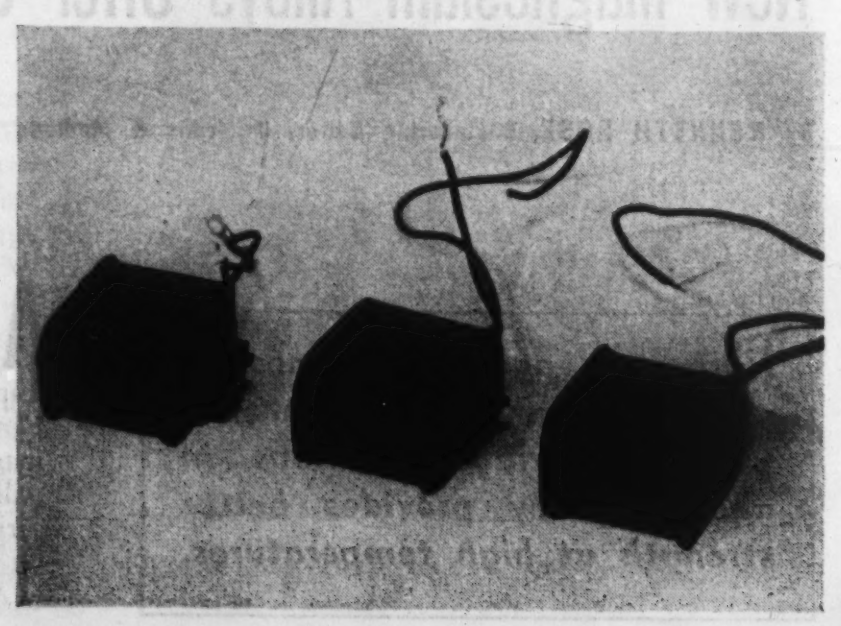


LUMINOUS SIGNS

Phosphorescent pigments are finding more widespread use daily in paints designed to identify doors, fire escapes and other vital safety or danger spots in total darkness. The phosphorescent materials become charged upon exposure to ordinary daylight or artificial light and continue to show up when all light sources are off. The signs shown here are typical of those being installed in a chain of New Jersey hotels.

GLASS CLOTH AIDS MAGNESIUM FORMING *With the advent of magnesium sheet as an airplane skin material came the problem of stretch forming the heated magnesium satisfactorily. At Glenn L. Martin Co. the answer was found in using 0.027-in. woven glass fiber blankets over the stretching dies. Grease which was used when forming similar parts of aluminum proved messy and difficult to clean, while rubber sheets which were satisfactory for cold forming smoked and smudged under the heat. In addition to aiding the actual forming operation, glass blankets help the sheet magnesium retain heat by insulating against transfer of heat to the form block.*

PLASTIC SEALING SLEEVES *A new method of insulating magnetic coils with plastic sealing sleeves has been developed by General Electric's Chemical Dept. The process involves a dilator solution in which the plastic material is immersed from 2 to 4 hr. When expanded to half again its normal size the sleeve is placed in position over the coil or other parts it is intended to cover. As the material dries, it shrinks to smaller than its original size, forming a tight fit around the product. In addition to its use on coils, sealing sleeves are being applied as coverings for cable ends, grips for pliers, wrenches and wire cutters, and as temporary protective covers for storing and shipping finished goods.*



Shown here are representative types of extruded shapes which can be produced in the new magnesium alloys.

New Magnesium Alloys Offer Superior Properties

by **KENNETH ROSE**, Engineering Editor, Materials & Methods

Higher strength in magnesium alloys results from use of zirconium; cerium additions in another alloy provides better strength at high temperatures.

AMERICAN INDUSTRY WILL HAVE an opportunity to utilize the light weight of magnesium in several new alloys designed to give higher strengths or improved properties at elevated temperatures. The Dow Chemical Co. has announced that a high strength magnesium extrusion alloy containing zirconium will be placed on limited commercial sale and several cerium-containing magnesium alloys can be obtained on order.

Announcement of commercial availability follows

two years of experimental use in several industrial applications so that the zirconium-containing extrusion alloy is not being offered as an untried product. A long period of laboratory work, and a study of the results of European practice, preceded the commercial testing. In the case of cerium-containing magnesium alloys, industrial testing is now being carried out, while the results of about ten years of German usage are open to the American industry as a result of the war.

Magnesium-Zirconium Alloys

The zirconium-containing alloy has been given the ASTM designation ZK60 and has the composition shown in Table I. The principal effect of zirconium in magnesium alloys is to produce and maintain a fine grain size. Refinement in grain size results in good strength properties, particularly toughness. As an additional advantage, zirconium reduces the iron content to an extremely low limit. This reduction of iron content materially improves the weathering resistance of the alloys. Zirconium cannot be used in magnesium-aluminum alloys because zirconium likewise reduces solubility of aluminum and causes it to precipitate. In the extruded ZK60 alloy, a desirable combination of strength properties can be obtained which were not heretofore available in magnesium alloys. The metallurgical improvement considerably increases toughness and raises the compressive yield strength. This makes the alloy containing zirconium a material to be considered in applications requiring resistance to shock and impact and for highly stressed applications requiring the light weight advantages of magnesium.

The ZK60 alloy exhibits good properties in the as-extruded condition but improvement is secured by a subsequent age hardening treatment as shown in Table II.

The aging is accomplished by heat treating the alloy at 275 F for 48 hr. It also is possible to obtain aging by heat treatment at a higher temperature (300 F) for a shorter time (24 hr.) but with some sacrifice in properties.

The development of maximum properties in ZK60 alloy is dependent more upon the processing technique than upon heat treatment. Close control of extrusion temperatures and a minimum ratio of area reduction of 50 to 1 between the extrusion press chamber and the extruded form must be maintained in order to develop maximum strength properties.

Good impact toughness is one of the outstanding characteristics of ZK60 alloy. Table III gives Charpy impact test results on the alloy in the as-extruded and aged conditions. The type of fracture obtained when a specimen of ZK60 is broken in the Charpy impact test is also an indication of the toughness. The zirconium bearing alloy does not exhibit the brittle type of fracture. The alloy also has less tendency to be subject to notch effect than certain of the high alloy content magnesium alloys. The ZK60 alloy compares favorably in fatigue strength to other high strength magnesium alloys. It tarnishes somewhat more readily, a result of its high zinc con-

Table I—Composition of ZK60 Alloy

Ingredient	Nominal Composition	Range
Zinc	5.5%	5.0-6.0%
Zirconium	0.50% min.	0.50-0.75%
Magnesium	Remainder	Remainder

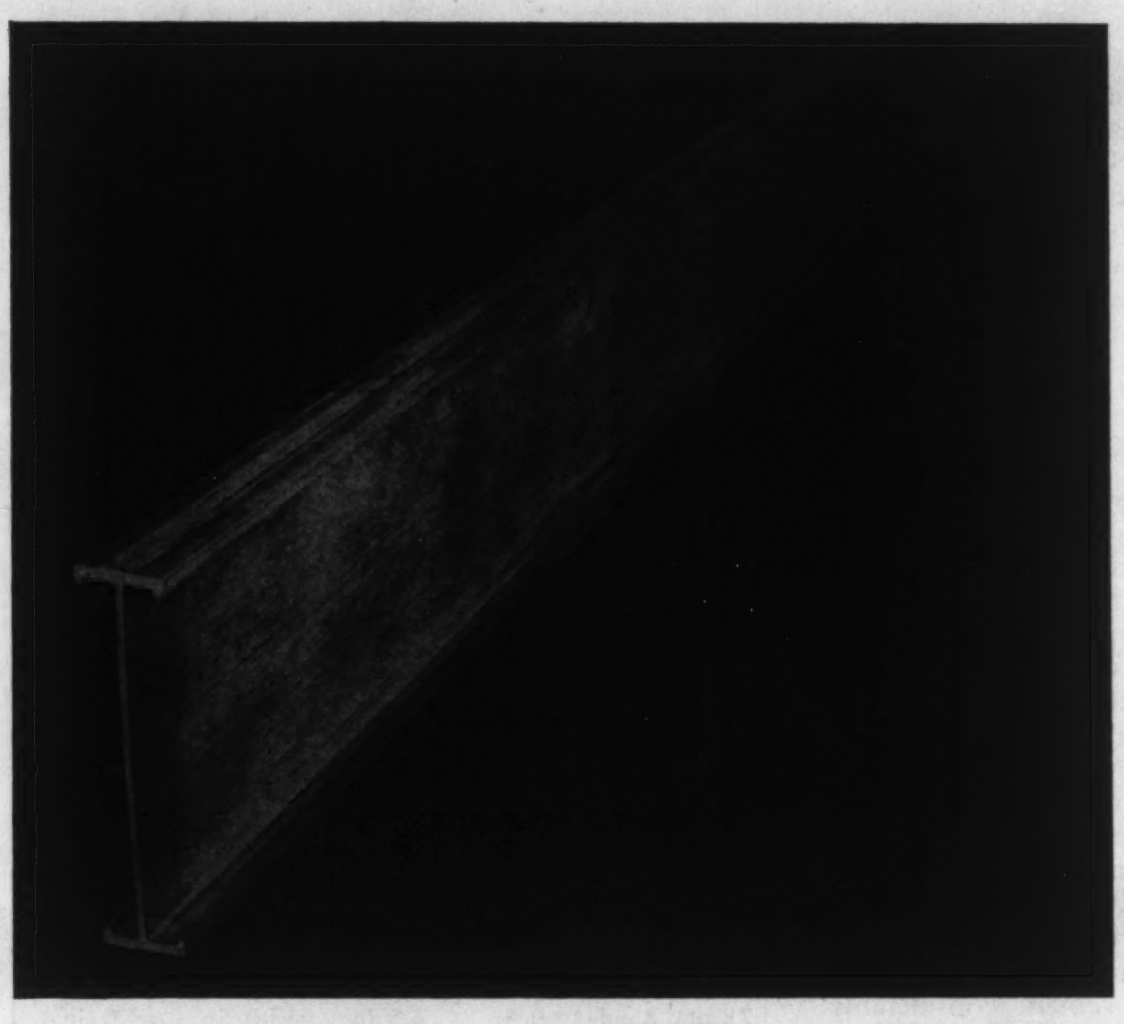
Table II—Mechanical Properties of ZK60 Alloy

Alloy	Condition	Tensile Strength Psi.	Tensile Yield Strength Psi.	Compressive Yield Str., Psi.	Elongation %
ZK60	As-extruded	49,000	38,000	34,000	10
ZK60A	Aged	53,000	42,000	38,000	8

Table III—Impact Toughness of ZK60 Alloy

Alloy Condition	Charpy Impact Cylindrical Specimen Circumferential "U" Notch		Standard Charpy Keyhold Notch	
	Plain	Notched	Plain	Notched
ZK60 As-extruded	13.0 ft.-lb.	4.0 ft.-lb.	35.0 ft.-lb.	4.0 ft.-lb.
ZK60A Aged	12.0 in.	3.5 in.	34.0 in.	3.0 in.

Billets being loaded into furnace for preheating prior to extrusion. Conveyors carry billets through the furnace.



The new ZK60 zirconium-containing magnesium alloy was used in making this large aircraft beam.

tent, but is amenable to the same protective surface treatments as magnesium alloys in general.

Like all magnesium alloys, the zirconium-containing composition requires generous radii when bending at room temperature. A minimum bend radius of 10 times the section thickness is suggested for room temperature forming. Warming the metal to 200 F permits the use of a minimum bend radius of 8t, while at a temperature of 500 F a minimum bend radius of 2t can be used. Forming temperatures should not exceed 550 F, although heating at temperatures of 550 or even 600 F can be done for 30 min. without effect on room temperature properties. Exposure at these temperatures for longer than 30 min. or heating above 600 F will cause a marked reduction in room temperature properties.

The creep strength of the zirconium-containing magnesium alloys is slightly lower than that of other high strength magnesium extrusion alloys, but shear and bearing properties are about the same. The typical shear strength of ZK60 alloy is 25,000 psi. The typical bearing strength is 77,000 psi. with a bearing yield strength of 55,000 psi.

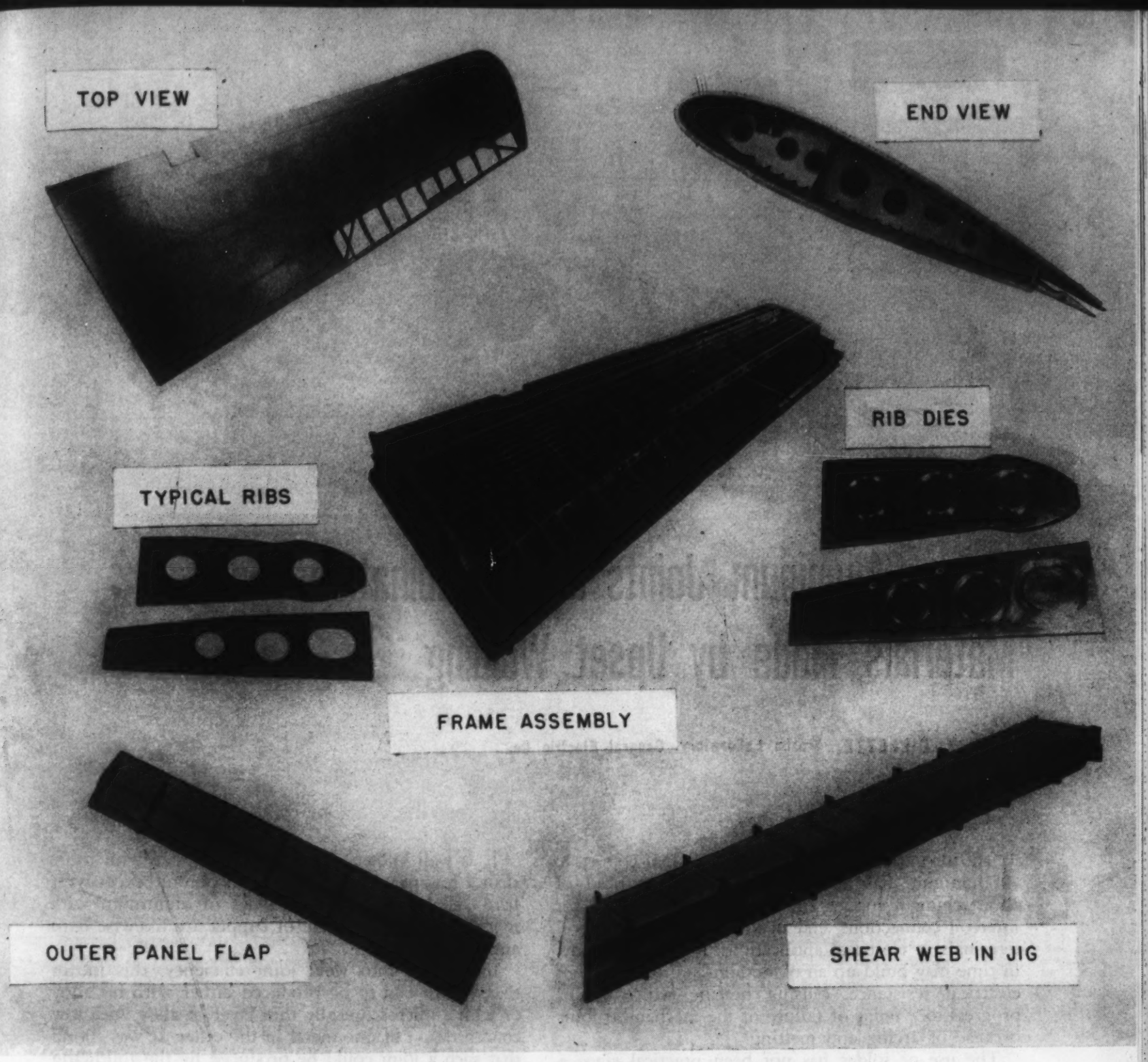
Riveting is recommended in preference to welding as a method of joining ZK60 since the alloy has limited weldability. For this reason the alloy is not recommended for structures requiring welded joints.

Only one alloy composition of the magnesium-zirconium alloy system is currently used in this country. This is the alloy containing 5 to 6% and a 0.5% minimum content of zirconium. In Great Britain zirconium containing magnesium alloys are also in use for high strength extrusions. They favor, however, a composition containing 3% zinc and 0.5% minimum zirconium; also in use is the same alloy containing 2% cadmium. Apparently some users in England prefer the straight zinc zirconium while others consider the addition of cadmium advantageous. American experience has indicated that the magnesium-zinc-zirconium alloy containing 3% instead of 6% zinc possesses good properties but must be extruded at slower speeds to develop the same strength as ZK60.

To date the applications for ZK60 can be considered as having been largely experimental in an effort to accumulate service performance data. The applications tried have all been found successful. ZK60 extrusions have been used in several types of experimental wings, and it has been successfully used for aircraft floor beams required to withstand high stresses. It is anticipated by aircraft designers and others that ZK60 will find expanded use in air frames and for stressed applications in all forms of construction.

Magnesium Cerium Alloys

The use of cerium as an alloying ingredient in magnesium for the purpose of raising properties of magnesium alloys at elevated temperatures has been known for some years. Such alloys have been used in Germany for at least ten years for elevated temperature service. Airplane engine forgings made from magnesium alloys containing cerium have been



Here are several airplane wing assembly details showing how ZK60 alloy is being used.

successfully used in both England and Germany. Magnesium-cerium containing alloys can be supplied in either cast or wrought form.

Many compositions of cerium containing magnesium alloys have been tried but the most successful all-around composition has been found to be an alloy containing 5 cerium and 1.2% manganese, designated as EM51. This alloy can either be cast or wrought. Current laboratory investigations, however, favor a magnesium-6% cerium composition for casting use. Heat treatment is recommended to obtain maximum properties for high temperature use. Solution heat treatment for 4 hr. at 1050 F followed by aging for 16 hr. at 400 F is the recommended heat treatment. Compared to strengths of other magnesium alloys at elevated temperatures, the improvement in the magnesium-cerium alloys becomes large at temperatures of 500 to 600 F. The most important gain is evident in creep strengths at temperatures approaching 600 F where the magnesium-cerium alloy is on a par with aluminum alloys in resistance to creep.

Cerium containing magnesium alloys are readily weldable and, like all magnesium alloys, they exhibit good machinability. Because of the price of the rare earths, cerium bearing magnesium alloys are somewhat more expensive than the others. Incidentally, cerium is added to the alloys as commercial Mischmetal, which contains about 50% cerium and the balance a mixture of other rare earths. Therefore, while the alloy is spoken of as a 5% cerium alloy, it actually is 5% mixed rare earths.

Magnesium cerium alloys are presently available only on an experimental basis and not in actual production. These alloys show promise of becoming important to the aviation industry, particularly for engine parts which will be operating at elevated temperatures. The addition of cerium to magnesium alloys is expected to extend the working range of these materials to as much as 300 F higher than the present limits.

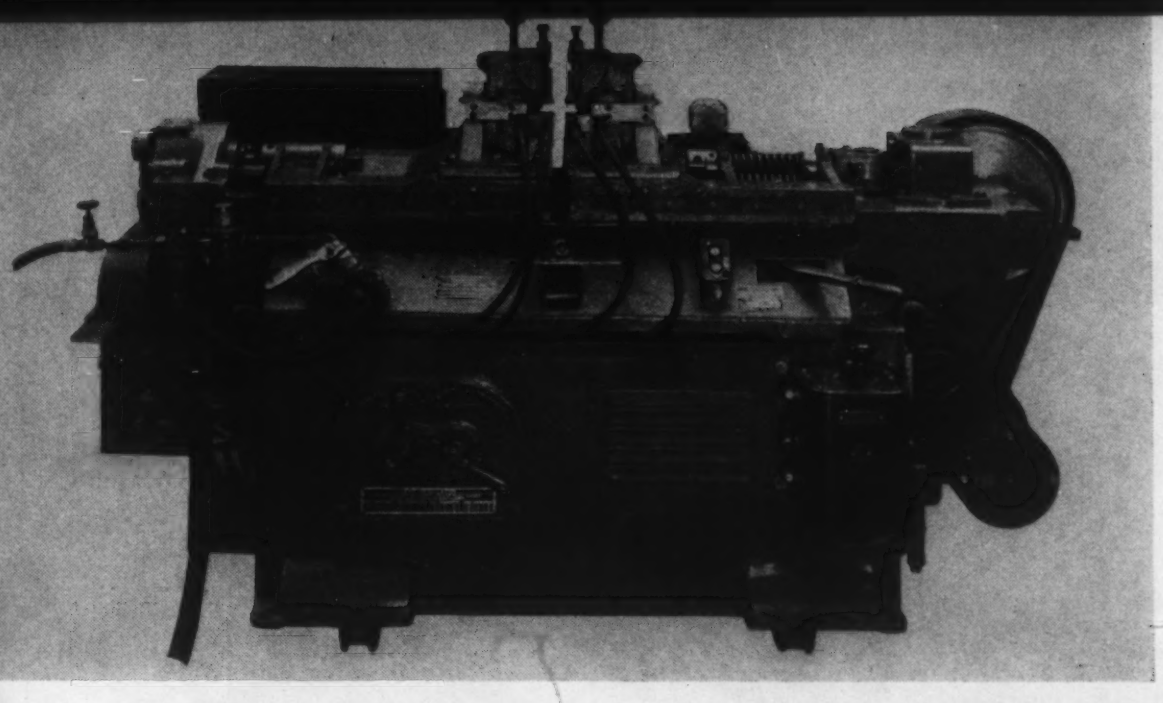


Fig. 1—This specially designed welding equipment is used to join aluminum to copper. Manually operated welders give erratic results.

Copper-Aluminum Joints and Combination Materials Made by Upset Welding

by **R. T. GILLETTE,** Works Laboratory, General Electric Co.

THE DEVELOPMENT OF UPSET WELDING copper to aluminum has been occasioned by the need of attaching a copper end to an aluminum coil for intercoil connections, and making connection to coil terminals in electrical applications. Mechanical joints in time may build up an oxide film and develop high electrical resistance, causing heating which might progress to a point of failure of the mechanical joint because of arcing and melting.

The use of solder has not been practical since a soldered joint on aluminum can fail because of electrolytic corrosion resulting under some conditions of high humidity and contaminated atmospheres. Also, a soldered joint has little strength at the temperatures at which some of these joints might be required to operate.

The development was started on a manually operated butt welder, and after a few trials a ductile weld was produced which could be bent back double at the joint. This gave enough encouragement to continue the investigation, and after a considerable time the following factors were determined.

One barrier to further use of aluminum in electrical equipment has been the need for a satisfactory method of joining this material to copper.

It is well known that alloys of copper with more than a few per cent of aluminum become excessively hard and brittle, and that alloys of aluminum with more than a few per cent of copper are likewise hard and brittle.

Interpreted into weld joint efficiency, this meant that a joint had to be produced either with no alloy or with a microscopically thin layer of alloy with low concentration of one metal in the other. It was found that such a joint could be produced by the following procedure.

The samples were prepared with a square end by machining. They were then clamped in the welder with approximately 1 in. overhand of the metal between the clamps. Just enough pressure was then applied to prevent arcing when the current was applied. The current was applied for a sufficient time to melt the metal at the interfaces still retaining low pressure. When the proper temperature was reached, the pressure was suddenly increased and the current switched off at the same time.

The quick increase in pressure almost completely extrudes the alloy from the joint, leaving a sharp line of demarcation between the copper and aluminum, and producing a ductile weld.

If high upset pressures are used for the entire time of making a weld, as the aluminum starts to soften due to its heating, it will upset like a flat head rivet before it becomes hot enough to weld at all.

If low pressure is used during the entire welding cycle, the copper aluminum alloy will not be extruded from the joint, and the resultant weld will be too brittle to be of any value.

After determining these factors on a manually

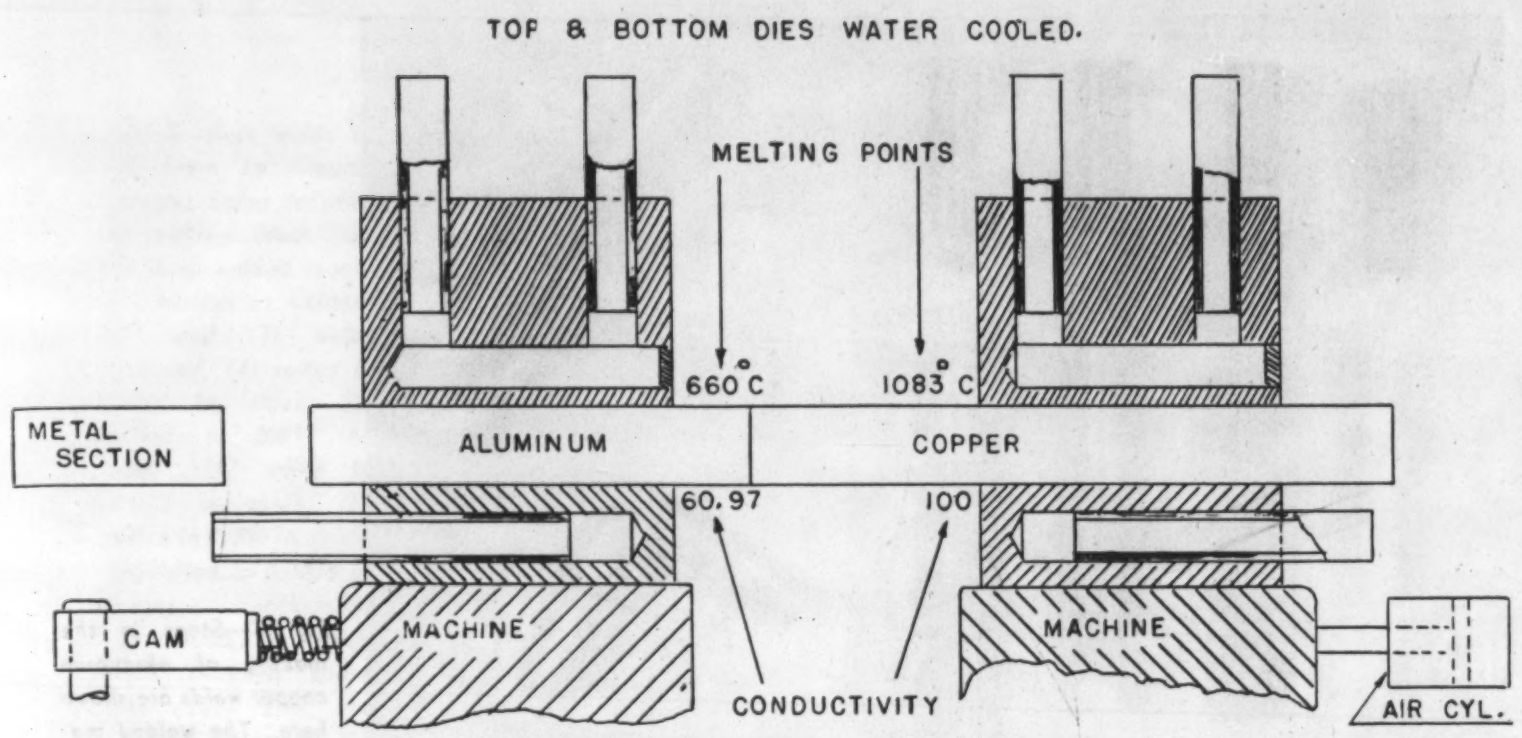


Fig. 2—The difference in melting points of the two metals is compensated for by having about 3 times as much copper as aluminum protrude from the welding clamps.

operated machine, a fully automatic welder was designed and built as it was found that the results on the manually operated welder were erratic because of the human element. This machine consists of a modified cam-operated butt welder. Both platens are arranged to move, the left-hand one being cushioned with an air cylinder.

To operate the welder, the pressure is adjusted on the air cylinder at the left-hand end of the welder to give a pressure several times higher than the coil spring shown on the right-hand platen. The motion of the cam is transmitted through the coil spring to the right-hand platen.

Both of these pressure devices are adjustable for the particular size material being welded. The welder operates as follows, with all adjustments properly made and the clamps set the correct distance apart. The work is clamped and the machine started. The welding current is turned on and off, at the proper time, by limit switches and auxiliary cams on the main cam shaft which control ignitron contactors. As the metal in the joint melts, low pressure is maintained through the spring.

When the proper temperature is reached through correctly adjusted time and current valves, the cam has traveled to a point where a steep rise on the cam compresses the coil spring against a stop. The right-hand platen then becomes a solid member, and the weld is upset or forged against the high cushioned pressure of the air cylinder, the welding current being turned off at the start of the high pressure application.

If the weld were to be upset against a solid stop, cracking would result in the immediate vicinity of the weld because of the hot short condition of the metal at temperatures below the melting point.

In making this weld, heat balance is another factor that must be considered. As aluminum melts at approximately 1210 F and copper at 1981 F, and the electrical conductivity of aluminum is about 61% that of copper and the same welding current must be used to heat both, some compensation must be made to prevent the aluminum from melting and running from the joint before the copper is hot enough to weld. This is accomplished by having about three times as much copper as aluminum protruding from the welding clamps.

The following tests were made to prove the reliability of the joint (See Fig. 1): (A) shows the normal preparation; (B) the joint as welded, showing the extruded metal which contains the brittle alloy; (C) the joint with the extruded alloy machined away; and (D) the results of tensile tests. The aluminum being softer than the copper, the major elongation and reduction occurs along with the failure in the aluminum. Note the cone shaped piece of aluminum left on the copper which indicates the toughness and ductility of the joint.

Photomicrographs at 100X show a good weld where only one small inclusion of alloy 0.00034-in. thick was found, and a brittle weld made with improper procedure where a continuous layer of brittle alloy 0.00236 in. was found over the entire area of the weld.

Further tests for ductility of the joint were made by rolling joints made in rectangular sections in a direction parallel with the joint from ¼ in. to as thin as 0.0003 in. with no intermediate anneal, and

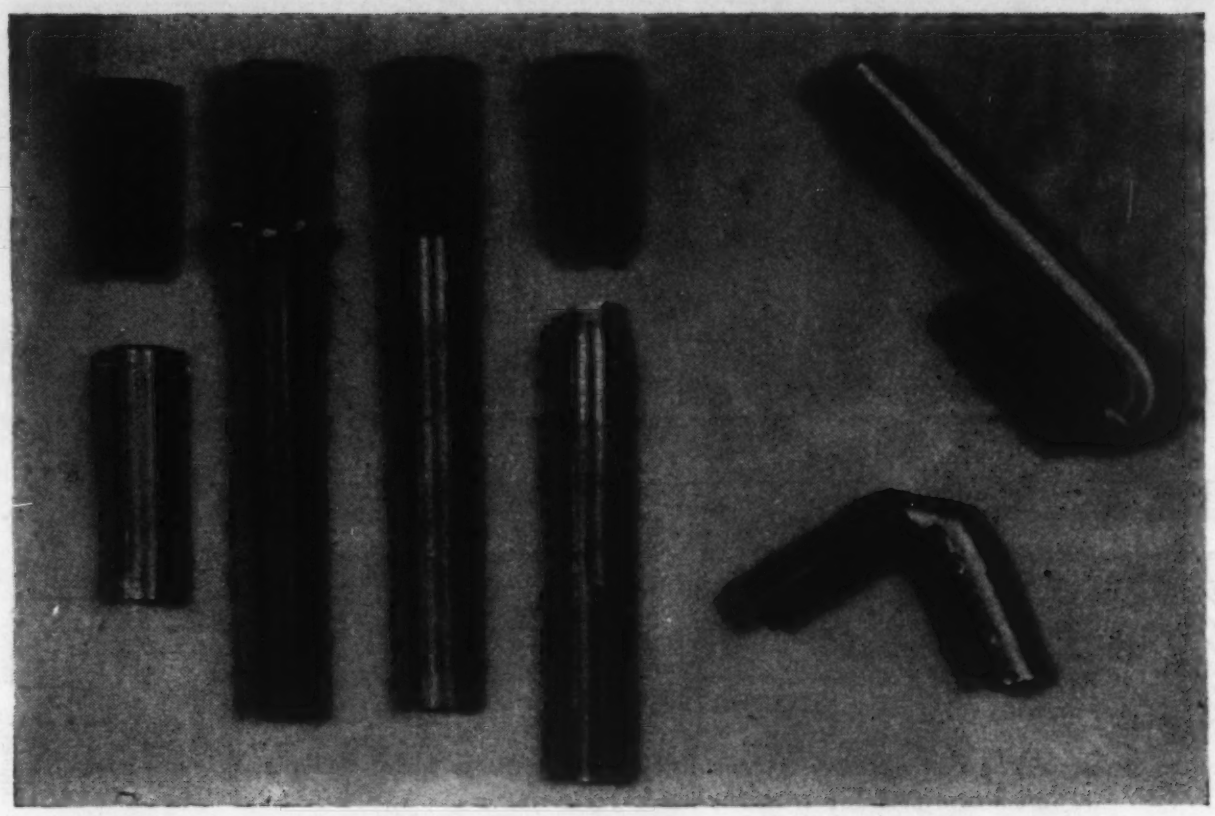


Fig. 3—Steps in the making of aluminum copper welds are shown here. The welded materials, before testing, are third from the left.

by pressing a ⅝-in. dia. round weld section to 0.015 in. in a hydraulic press. No indication of splitting or cracking was noted in these tests.

Tests for corrosion were made with ⅝-in. dia. round rods. Five of these samples were pulled, as welded. The average strength was 12,100 lb. total on a ⅝-in. dia. rod. Five were placed in salt water spray test for 170 hr. then pulled with an average strength of 11,500 lb. total on a ⅝-in. dia. rod.

Five were placed in wet steam for 30 days, then pulled with an average strength of 12,250 lb.

From these tests it appears that the welded joints were practically the equivalent of the straight aluminum and that subjecting them to salt spray or steam did not lower their properties. The joints were also tested for their electrical resistance. No joint resistance was detected with the samples tested.

Resistance of 1.75 CM length of the copper section and of the aluminum section, also across the joint, was measured with the following results:

Copper section	0.0000051 ohm
Aluminum section	0.0000086 ohm
Average	0.0000069 ohm
Joint section	0.0000069 ohm

Due to the line of demarcation between the copper and aluminum sections, not being uniformly at right angles to the axis and to the variations in diameters, the measurement of resistance across the joint might be in error by about 2%. The resistance of this joint is therefore not more than 0.0000002 ohms.

These joints also behave satisfactorily under vibration, but due to the abrupt transition from the hard copper to the soft aluminum are not too satisfactory under severe shock.

There is one caution to be observed in any subsequent work or fabrication in close proximity to these joints, such as welding, brazing or heat treating procedures. That is not to bring the copper-aluminum joint above the melting point of the copper aluminum eutectic alloy, about 1018 F, as copper-aluminum in such intimate contact will rapidly diffuse into each other and form a layer of eutectic alloy which will melt at the eutectic alloy melting point, and thus the joint fails.

This joint was primarily developed to further the substitution of aluminum for copper coils on heavy,

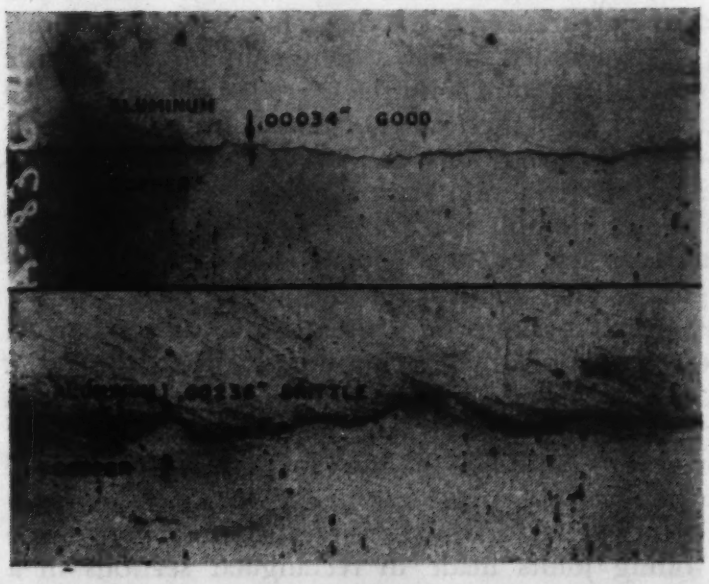


Fig. 4—Alloying of the materials is undesirable. These 100 X photomicrographs show good and bad welds.

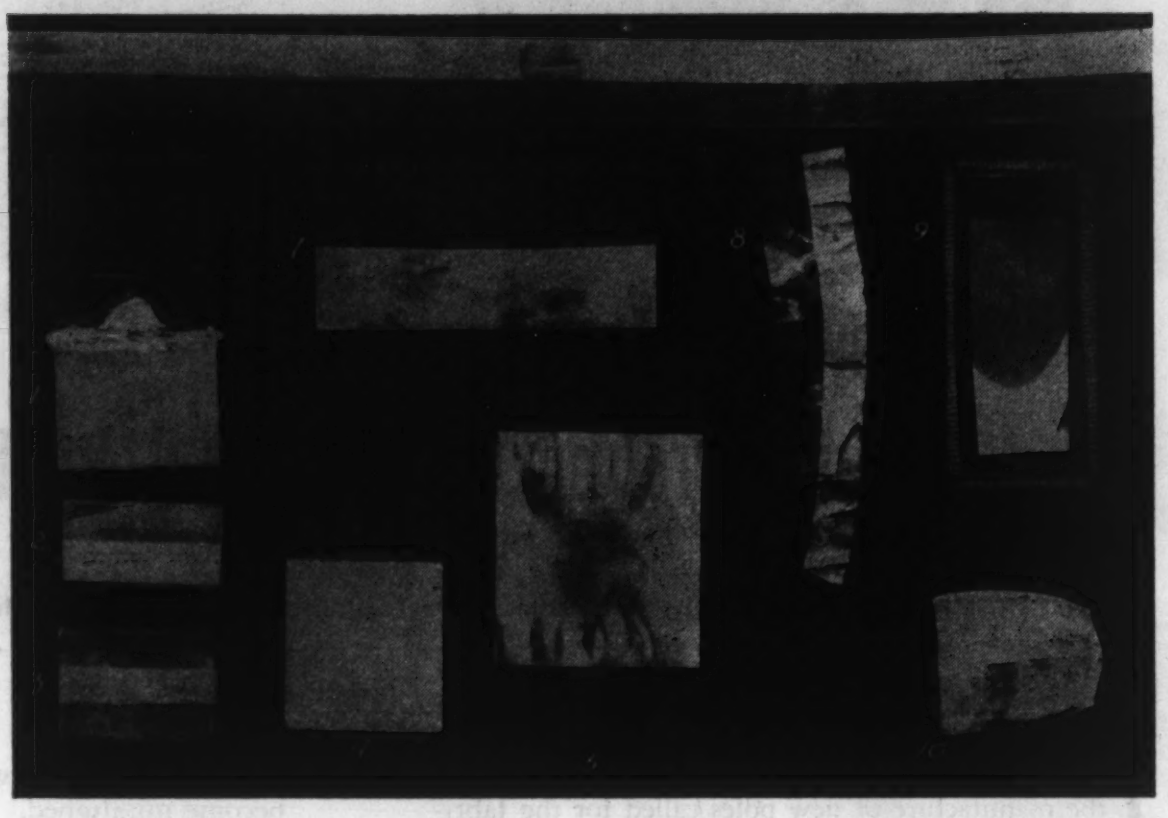


Fig. 5—Butt welds of aluminum to copper, samples being reduced by rolling from ¼- by 2-in. welded stock: (1) section as welded; (2) and (3) welds trimmed; (4) rolled to 0.062 in. thick; (5) rolled to 0.011 in. thick; (6) rolled to 0.010 in. thick; (7) rolled to 0.006 in. thick; (8) rolled to 0.0035 in. thick; (9) pack-rolled to 0.0003 in. thick, held between glass; and (10) ⅜-in. dia. rodweld pressed flat (0.15 in. thick).

high-speed rotating electrical equipment, where the rotating parts may weigh many tons. The use of aluminum reduces the weight of the coils approximately 50%, which is of major importance in lowering centrifugal stresses.

This type of joint is also used on the moving coil of an electrical measuring instrument wound with aluminum wire 0.005 in. in dia., replacing a copper winding. The reduction in weight reduces inertia so the needle will come to rest with a minimum of swing. This coil weighs only 0.1655 gram. Two small strips of thinly rolled (0.003 in.) copper-aluminum are used to connect the aluminum wires to the terminals, by folding over the aluminum end of the strip and spot welding the aluminum wire between the fold, and then soldering the copper end to the coil terminal. This method gives a permanent joint not susceptible to electrolytic corrosion.

This method of welding has been used for several other applications of an entirely different nature than coil weight reduction, where it is desirable to use aluminum to replace copper for various reasons. But a partial use of copper is required for ease of fabrication.

In refrigeration it is sometimes desirable to use aluminum for evaporators or condensers, as it may have better sanitary properties in various foods acids, lower cost than some other non-corrosive materials, better heat conductivity, and be more readily available. In making up the pipe connections between these and other parts of the refrigerating system, it is common practice to weld together a piece of copper tubing and a piece of aluminum tubing as a unit. These units may then have the aluminum tube welded to the aluminum fabricated part, and the copper tube end may be soldered, brazed, welded or used in a mechanical connection to connect to the compressor or other part of the system. These joints may also be used on bus bars, cable splicers, connectors, terminals, chemical equipment, and electrolytic cells.

The development of upset welding of copper to aluminum opens up a new method of fabrication which should find wide use wherever it is desired to join copper to aluminum but where the other welding processes would result in a brittle weak joint because of the inclusion of copper and aluminum alloys.

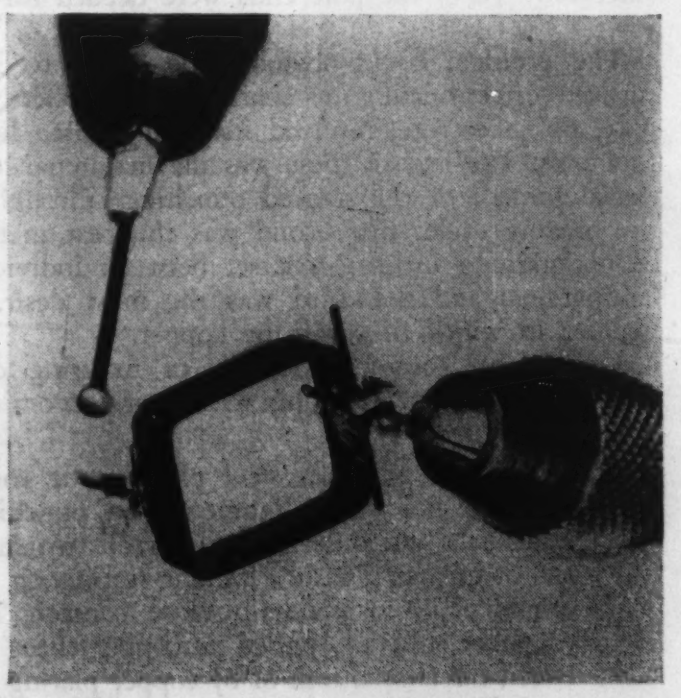
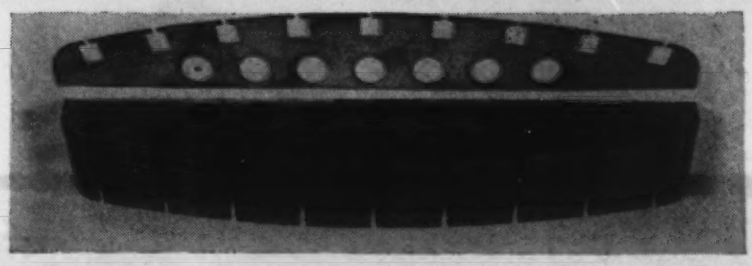


Fig. 6—One use of this method of welding is to provide for the substitution of aluminum on moving coils of electrical instruments.



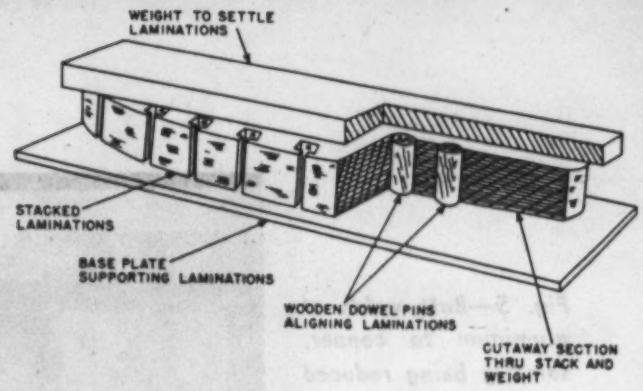

WEIGHT TO SETTLE LAMINATIONS
STACKED LAMINATIONS
BASE PLATE SUPPORTING LAMINATIONS
WOODEN DOWEL PINS ALIGNING LAMINATIONS
CUTAWAY SECTION THRU STACK AND WEIGHT

Fig. 1—Here is a generator pole end fabricated by copper brazing. Fig. 2—(right) shows the way in which wooden dowels were employed.

Wooden Dowels Solve Fixturing Problem in Brazing Steel Laminations

by S. DeDOMENICO and A. SQUIRE, Materials Engineering Dept., Westinghouse Electric Corp.

IN THE REPAIR OF a large water wheel generator, the manufacture of new poles called for the fabrication of new pole ends which had previously been machined from solid stock. Inasmuch as the preparation of these pole ends (see Fig. 1) from solid material entailed considerable expense and time, the idea of manufacturing the pieces by making a brazed assembly of stacked punchings was suggested. Accordingly, enough punchings were made to construct 16 pole ends.

The requirements to insure that the brazed assemblies would be satisfactory substitutes for the previously broached pieces were that the laminations be completely brazed to one another and that the holes and slots be perfectly aligned. The edge of the stack was also required to be normal to the contacting face of the pole end. In order to meet these requirements it was obvious that some method of fixturing was indicated, but the fixtures could not be too expensive since only 16 of the pole ends were needed for the job.

The problem could obviously be best solved by furnace copper brazing in a controlled atmosphere furnace and, therefore, resolved itself into three lesser problems. The first of these was the maintenance of the alignment of the stacked punchings throughout the brazing cycle; the second was the best method of maintaining intimate contact between individual laminations; and the third was the most desirable manner in which to apply the copper.

The several common methods of fixturing considered includes the following, with their concomitant disadvantages:

1. The use of stainless steel pins in the round holes to hold the alignment, the punchings lying in a horizontal plane between two stainless steel plates with a weight resting on the upper plate to maintain close contact. The copper would be applied as copper sheet between the laminations or by copper plating the steel. The difficulty with this method was that the steel pins were apt to prevent the upper weight from bearing on the stack or, if the pins were short, a few of the laminations might become misaligned.
2. The assembly of the punchings between stainless steel plates with stainless steel bolts used to maintain alignment and contact. This method involved the machining of the plates and the bolts, a relatively expensive procedure.
3. The manufacture of a frame of stainless steel to enable alignment of the punchings by their outer edges. A weight would be used to keep the laminations in close contact. Disadvantage —same as in (2).

In view of the failure of any of the above common methods to solve the problem at hand, the idea of using wooden dowels in the assembly came to mind. By this means, the laminations could be held in perfect alignment until they were in the furnace, whereupon the pins would char and permit a weight to bear on the upper surface of the stack. The work would be reduced to a temperature below the melting point of copper before it was removed from the furnace.

The last method was used with outstanding success. Two or three wooden dowel pins were driven into the holes of the stacked laminations (as shown in Fig. 2) and a weight was placed on top of the stack. Copper was supplied by plating alternate punchings to a thickness of 0.002 in., and a number of assemblies could thus be brazed simultaneously in an electric furnace using an Exogas atmosphere. After the work had attained a temperature of 1100 C (2012 F), it was held for a few minutes to assure complete flow of the copper, and the furnace temperature was then reduced to 1060 C (1940 F) before the brazed pieces were withdrawn into the cooling chamber of the furnace, where they were cooled to room temperature in an Exogas protective atmosphere.

It is believed that this novel use of wood as a fixturing material during the brazing of assemblies of which there are only a limited quantity can be applied generally to problems of this type.

MATERIALS & METHODS MANUAL

This is another in a series of Manuals on engineering materials and their processing published as special sections in Materials & Methods. Each manual is complete in itself and is intended to serve as a reference book on the subject covered. These manuals provide the reader with useful data on characteristics of materials or fabricated parts, and on their processing and application. Preceding manuals have taken their places in the permanent reference files of thousands of readers.

39

Permanent Mold Castings

—Ferrous and Nonferrous

by Herbert Chase

Castings produced by the permanent mold method offer many advantages not to be obtained through other methods. In this manual Mr. Chase discusses when and where permanent mold castings should be used; the design factors which must be taken into account; materials which can be cast by the method; and other information pertinent to the intelligent selection and application of such castings.

Contents

Introduction . . . . . Page 76
Production Methods and Equipment . . . . . Page 78
Material Selection . . . . . Page 79
Dimensional Tolerances . . . . . Page 83
Production Conditions Affecting Design . . . Page 83
Design Rules . . . . . Page 84

July 1948

Materials & Methods

Pistons, cylinder head, housing parts and a supercharger impeller produced as aluminum alloy permanent mold castings. The cylinder head required a sand core. (Courtesy: The Permold Co.)

Introduction

According to American terminology, a permanent mold casting is one made in a metal mold that is poured under a gravity head and without centrifuging. The mold itself is commonly cast in gray iron, alloy iron, or bronze, usually machined, and, strictly speaking, is not permanent, as it is subject to deterioration and often requires renewal or replacement for long run work or for use with alloys melting above 1000 F.

Actually, the word "permanent" is intended to indicate that the mold serves for making long runs of castings (often many thousands). It is not necessary, as with sand castings, to make a new mold for each casting or gate of castings and it is this fact that makes permanent mold casting more efficient in many cases, from a labor standpoint, than sand casting.

In England, the permanent mold casting is referred to as a "gravity die casting." This term is not sanctioned in American usage partly because of possible confusion, if the word "gravity" is omitted, with that form of die casting in which metal is forced into the die under a pressure many times greater than gravity. Die casting (under high pressure) is a different process, done with different equipment and usually with different alloys and by specialists who, as a rule, make only die castings.

Most makers of permanent mold castings make also a secondary type often termed "semi-permanent" mold castings because the cores used are made from dry sand in core boxes, exactly as are cores for sand casting. Actually, the semi-permanent mold itself can be used as often as when metal cores only are applied but, since one or more new sand cores are required for each casting, the term "semi-permanent" has gained sanction. Semi-permanent mold castings are considered here as one form of permanent mold casting.

There is, in fact, still another form of mold that might be called "half-permanent" as it uses a metal drag and a sand cope. The drag is the "permanent" part and the cope is molded exactly as for sand casting. Either dry sand or metal cores can be used. This type is useful but is highly specialized and is excluded from this discussion.

Importance and Application

Permanent mold castings are definitely intended for quantity production and constitute an important class of castings. In certain respects they are intermediate between sand castings and die castings but they also have some distinctive and somewhat exclusive properties which make them useful where neither die castings nor sand castings are applicable or at least are less satisfactory.

As over-all costs are often less per casting in the quantities required than for sand castings, permanent mold castings frequently displace sand castings, and this alone gives the permanent mold casting an important status. And, since the permanent mold usually costs considerably less than a die for die casting, the permanent mold casting sometimes costs less *for a given*

quantity (mold and die cost included) than the die casting. Moreover, as some permanent mold castings can be had in gray iron, whereas only *nonferrous* die castings are available, the permanent mold casting becomes important from that angle. It has also been possible to make permanent mold castings that are larger in size and that weigh more than any die casting (especially in aluminum alloys) and this, too, opens a large field not open as yet, at least, to the die casting.

In consequence of these and other factors, permanent mold castings have gained rapidly in importance, chiefly at the expense of sand castings. This growth has been accelerated by high labor costs and labor scarcity for sand casting. There usually is less total labor per permanent mold casting than per sand casting (in the quantity range favorable to the permanent mold casting), and this advantage is further increased in most cases because of lower labor cost (as well as lower machine charges) for machining permanent mold castings as compared with sand castings.

Today, the permanent mold casting ranks high in output among aluminum castings; has gained considerable favor in the ferrous casting field; has demonstrated utility for certain magnesium castings and for certain types of copper base castings; holds only a minor place among zinc base castings, and is useful for some forms of lead and tin castings.

Applications in aluminum alloys include a very large volume in pistons and cylinder heads for automotive engines; extensive use in certain other automotive applications, including airplanes and army tanks; considerable use in electrical appliances such as washing machines (chiefly agitators), flatirons and waffle irons; and a variety of sundry uses such as kitchen ware, business and other light machine parts, lubricating devices and the like.

Permanent mold castings in ferrous alloys have relatively few producers but they have developed specialized equipment. One maker states that the castings are limited to 12-in. maximum in diameter and length and 18-lb. maximum in weight. Applications include household refrigerator compressor cylinder blocks and heads, carburetor and hydraulic brake parts, bearing retainers, washing machine gear blanks, connecting rods and crankshafts for small refrigerator compressors, valve bodies, V-belt sheaves, flatiron sole plates, typewriter parts and many similar castings, including many requiring cores made in dry sand. One plant alone produces in excess of 100 tons a day of gray iron permanent mold castings and has reached some 50 million castings a year. This is large as compared with the total for other permanent mold castings. Iron, of course, is low in cost per pound, and labor per piece has been minimized by mechanized setups, some of which are quite elaborate.

Within the size and weight limits available, it is possible to produce many gray iron castings now made in sand as permanent mold castings, provided the shape is one that can be ejected from the mold and that any core needed is such as can be placed readily in the mold. Match plate work involving many parts per gate is often better adapted to sand casting than to permanent mold casting, however.

Permanent mold castings in copper alloys have been used chiefly as gears, or parts requiring much higher strength or better bearing properties than have been obtained in permanent mold aluminum castings. Aluminum bronze has the fluidity needed for permanent mold castings but its rather high melting point is not conducive to long mold life. Alloy steel is used for molds rather than cast iron in the case of one of the largest producers of this type of casting, but these molds are not "painted" with refractory as are the molds for aluminum, iron and magnesium.

Magnesium permanent mold castings are produced on a slowly increasing scale but casting difficulties are such that output has been limited to those parts requiring lightest weight, chiefly for aircraft or military applications.

Lead and lead alloys are readily cast in permanent molds, including slush molds, but types of application are limited because the metal is soft, low in strength and subject to cold flow. Uses include shields or other parts for expansion bolts and parts for lead storage batteries, but some slush castings are also made.

Zinc alloys are easily cast in permanent molds but their use more or less parallels that of slush castings in the same alloys. Slush castings are a special form of permanent mold casting used extensively for making parts such as those for lamps, lighting fixtures and novelties. Casting is done in bronze molds that usually are highly polished and often engraved. A coating of stove polish is applied once or twice daily.

In slush casting, the mold is mounted so that it is readily tilted and, after filling, the mold is inverted and metal remaining in molten form is run out, leaving only a thin frozen shell against the mold wall to be ejected. This shell is usually bright and is well adapted to plating but has much lower strength than zinc die castings which, in general, are much more rapidly made. The outstanding success and low cost of zinc die castings has resulted in relatively minor use of zinc permanent mold castings other than slush castings, partly because the process is slower. On the other hand, as mold cost is less than for dies, the cost per casting is sometimes lower when runs are comparatively short. For this reason, applications are mostly decorative and in fields where style changes require that molds be changed quite often.

Advantages and Limitations

The following are among the significant advantages of permanent mold castings:

1. A single metal mold serves, as a rule, for making from 3,000 to 25,000 or more castings; it is not necessary, as with sand casting, to make a new mold for each casting or gate of castings.
2. Castings are dense and the rapid chilling makes for a favorable fine grain structure.
3. In general, castings are smoother than sand castings and this favors appearance in addition to tending to lower machining and finishing costs.
4. Production is rapid, as the casting chills quickly and can be ejected soon after pouring is completed.
5. Dimensional tolerances can be held more closely than for sand castings, hence less allowance for machining is needed and total machining costs are below those for equivalent sand castings.
6. In general, less metal is required per casting than for sand casting and less scrap results.
7. Usually holes can be formed by metal cores and can be held within close dimensions; holes smaller than are feasible in sand casting often can be cored.
8. Porosity is commonly the lowest for any form of casting (except perhaps for some centrifugal castings) and makes its use advisable to produce castings subject to fluid or gas pressure.
9. Inserts often can be cast in place, whereas this seldom is possible in sand casting.
10. Sizes that are larger than are practicable in die casting can be made, and alloys not suited for die casting, including ferrous alloys, can be used.
11. The range of alloys available is wider than for die casting, and some alloys can be heat treated with beneficial results not attained in die cast parts.
12. Cores of certain shapes, especially sand cores, not feasible in die casting can be applied.
13. As strength superior to sand casting can be attained, thinner walls for a given strength can be used (except, perhaps for thinnest sections castable) and corresponding metal economy can be attained.
14. Molds cost less than dies for die casting.
15. In general, no casting machine is needed.
16. Tooling costs, especially for machining, are often lower than for sand castings.

Limitations include:

1. Certain shapes that are practicable in sand casting or in die casting are not in permanent mold casting.
2. Maximum size is less than that advisable in sand casting and greater (at least in some alloys) than for die casting. Minimum size is greater than for die casting.
3. Minimum wall thickness is greater than for die casting and some other types of casting.
4. Dimensional limits cannot be held as closely as with die casting.
5. A considerable investment in molds is required, usually more than for patterns for sand casting.
6. Molds are subject to considerable deterioration and involve significant expense in coating and other upkeep.
7. Production rates usually are much below those for die casting.
8. Where sand cores are required, core boxes are needed and one or more cores must be made for each casting produced.
9. Considerable experimental work, including changes in gating, is commonly needed before satisfactory castings are produced and the technique necessary to reduce rejects to a minimum is established.
10. For large castings, some type of machine often is needed to operate molds.
11. Labor per casting (excluding that for making molds) nearly always is higher per casting than for die casting.
12. Smoothness of castings is not equal to that attained in die casting.

As with other types of castings and, in fact, all items intended for quantity production, it is logical for the designer to check attainable advantages against limitations imposed and to make such compromises as may yield optimum results. Where other methods of production appear feasible, their relative advantages and limitations deserve to be weighed with a view to securing that type of part which affords lowest cost consistent with satisfactory performance.

Production Methods and Equipment

Although the methods of making permanent mold castings are basically simple, considerable experience is required, first, in making a suitable mold, next, in keeping it in satisfactory condition and, finally, in using the mold in such a way that castings are turned out at an efficient rate with a minimum of rejects.

In the average case no machine is needed, as the mold can be opened, closed and locked by hand. In some permanent mold work, however, a machine is used. It may be operated by hand levers with or without toggles, or by air or by hydraulic means. The latter applies usually to rather large molds. Some machines for casting iron are designed for as many as a dozen molds, which are carried through several stations where ejection of the casting, cleaning the mold, coating it with carbon, placing of cores, pneumatic locking, casting, cooling and unlocking are done at successive stations. In such molds, special provisions for air cooling are made but, in most permanent mold work, only cooling by radiation is done as the mold must be kept reasonably hot to produce good castings.

The average permanent mold for nonferrous alloys has one or more sections that are pivoted or arranged for longitudinal motion by hand, often while supported and guided on a flat bed. Alloy steel cores are often used in casting nonferrous alloys and usually are pulled by pinch bars, toggles, rack and pinion or screw mechanisms before the mold is opened. If opening the mold does not free the casting completely, push out pins sometimes are provided for ejection. Some metal cores, especially those that produce undercuts, are made in two or more pieces, parts of the core being collapsed or knocked out. Such cores are expensive and their operation slows the casting cycle (*e.g.* for producing pistons), but the savings in metal and in machine work offset the extra core cost and extra operating time.

Metal cores have to be shaped, generally with considerable draft, to facilitate withdrawal and either the core as a whole, or each of its pieces, must be of a size and shape that can be withdrawn through the hole cored. If the core is so shaped that it cannot be withdrawn through a cored opening, it must be made from sand. For iron castings all cores are of sand. Sand cores are made in core boxes for each casting, exactly as for sand casting, and have to be positioned by prints or, in the case of some nonferrous castings, by a metal core around which the sand core fits.

Each mold has, as a rule, a sprue hole or holes, runners, gates, vents and often risers or their equivalent. In general, the sprue hole extends to the bottom of the mold and metal flows upward through runners and gates to fill the mold cavity and risers by gravity, preferably in such a way that true progressive solidification occurs. Often, the gate is a slot or series of openings along the parting, so arranged that feeding takes place at a higher and higher level as the mold is filled. Metal that freezes in feeding passages and risers must come away with the casting, of course; hence these passages are made at mold partings.

The simplest mold usually has a flat parting, but many molds require two or more partings to clear the casting when it is removed. If metal cores are used, they must be withdrawn before the casting shrinks too tightly thereon. With the light alloys that have high shrinkage and are hot short, castings may crack if cores are not pulled or the casting freed from the mold before shrinkage is completed. In this case, the operations must be so timed that the casting is solid enough not to be distorted significantly, and yet has not shrunk enough to cause cracking.

Molds have to be clamped securely enough not to spring open as a result of metal pressure under gravity head or as a result of any tendency to warp under heat. Even then some flash often is formed at mold partings or around movable cores and has to be trimmed off in a subsequent operation, usually when gates are cut off.

Pouring is always done by gravity and usually from hand ladles filled from a metal pot, furnace or cupola. Large light metal castings often have to be poured at two or more sprue holes simultaneously; otherwise metal would freeze before the mold could be filled. In some foundries, a single furnace provides metal for filling several molds in rotation.

Usually it is necessary to fill the mold on a fairly regular cycle, generally from 15 to 30 times an hr., to keep the mold at such a temperature that rejects are avoided or minimized. It often requires considerable experimenting to determine the correct timing and to train the operators to make acceptable castings consistently. In slush casting, parts of the mold sometimes are dipped momentarily in water, or water is poured over certain areas to prevent the mold from getting too hot.

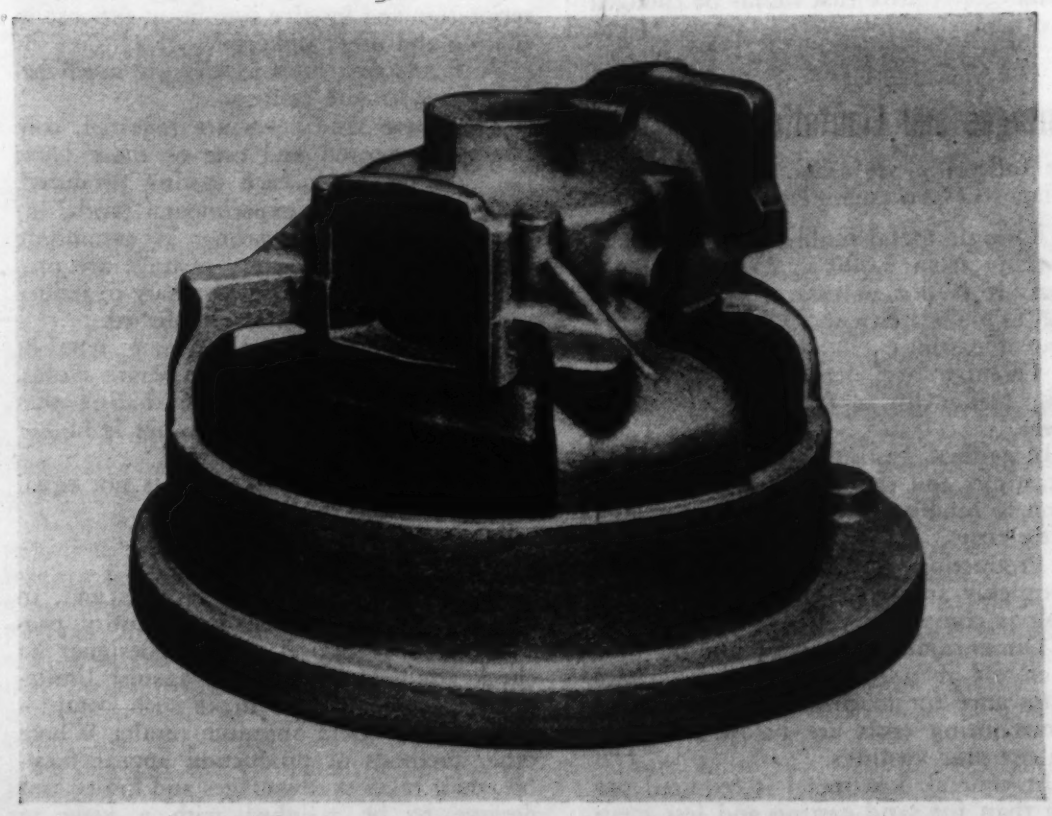
For casting aluminum and magnesium alloys, molds must be coated, as a rule, once or more each shift with a refractory and binder (such as a special clay or French chalk suspended in a waterglass solution) usually applied by spraying or brushing, and then smoothed with steel wool. This coating not only protects the mold surface from erosion and checking but helps to control solidification. Where chill is needed, the coating is kept thin or can be omitted and, where no chill is wanted, a thicker coating is applied so that the adjacent metal will not freeze before other parts of the casting freeze.

For low melting alloys coatings are not always required but, for some zinc castings molds are coated with stove polish. For copper alloys some casters (who use alloy steel rather than iron molds) occasionally coat the molds with Oildag. These molds check in time but, as no pressure is applied, checking may not affect the surface of the casting significantly.

Molds for ferrous castings are given both a refractory coating (say, once a shift) and a smoke coating during each casting cycle, at least in the practice followed by one prominent foundry making permanent mold iron castings.

Mold life varies with the alloy being cast. With iron, 3,000 to 10,000 castings may be made. With aluminum, 10,000 to 25,000 or more castings often come from one mold. Much depends, however, upon dimensional limits set and upon mechanical wear. Cores often have to be replaced before molds wear out. In some cases, at least, there is considerable deterioration of molds when they stand idle; hence the possible effects of intermittent use ought not to be overlooked.

In general, the customer pays for the first mold and the foundry maintains the mold or replaces it if necessary, but commonly has to adjust the price per casting to include mold upkeep and replacement costs, as they are proper operating charges. There is little that the designer can do in this regard except to design the casting for



The advantages of permanent mold castings are now extended to gray iron for such parts as this produced by Eaton Mfg. Co.

minimum mold cost consistent with securing satisfactory castings and to keep as-cast tolerances as liberal as other conditions admit.

Mold Construction

Although mold design usually does not directly concern the designer of the casting, the more he knows about the types of molds employed, the better equipped he is to adapt the design of the casting to that of the mold.

Most molds (except for low melting alloys) are cast in Meehanite or some similar alloy iron that is resistant to heat and to such dimensional changes as otherwise would result from repeated heating and cooling. In general, the cavities are cast fairly close to size but with allowance for machining to final size. As a rule, mold walls range from ¾ to 2 in. in thickness, when iron molds are used, and commonly follow the approximate contour of the casting. Mold sections have to be machined at partings, for metal cores, and on surfaces that guide the motion of movable portions. Molds always must be so shaped and parted that the casting can be removed quickly and without significant distortion when the mold is opened.

Some bronze permanent mold casting is done in molds of wrought alloy steel similar to that used for brass die casting but the mold is adapted, of course, to gravity pouring and is opened and closed by a simple hand operated machine with suitable core pulling attachments.

Permanent molds employed for casting lead, tin and zinc (including slush casting) are cast from bronze, often in several pieces. The patterns used are often made from plaster, and little allowance is provided for machining as, in general, only scraping and polishing are done, the cavities being cast close to size.

All molds have to be locked before being filled but simple screw or toggle clamps are adequate for average small molds. Some, chiefly of larger size, are arranged for pneumatic or hydraulic locking and actuation.

Molds for slush casting, and some making solid castings in the low melting alloys, are arranged on trunions for tilting while being filled and for pouring out excess metal before it freezes.

Material Selection

Optimum results are not always attained, of course, with the cheapest material even when its properties make it satisfactory for a given application. But, in general, economic considerations are likely to force or to make it wise to employ that type of available material which, when fabricated and ready for use, will insure the lowest *over-all* cost compatible with satisfaction in service. Consequently, such items as fabricating costs; tooling costs, including molds; design limitations; ability to meet service requirements; type and expense of applied finishes, if needed; and certain other items demand attention.

Gray Iron

As a rule, ferrous materials cost least per lb. and, as gray iron is the only ferrous material suited for casting in permanent molds, its possible use must be given attention. Hoenicke gives the properties listed in Table I for gray iron cast in permanent molds when metal at the spout has a temperature of about 2800 F and the following composition (presumably optimum for this purpose):

Total carbon	3.40 to 3.60%
Silicon	2.40 to 2.60%
Manganese	0.70 to 0.90%
Phosphorus	0.30% max.
Sulfur	0.10% max.
Iron	Remainder

All properties given, except transverse breaking load, are better in thin than in thick sections. No data on impact strength or elongation are included. They are presumed to be low, as in most gray iron. Heat treatment improves mechanical properties, and most of those given are superior to the corresponding properties of most nonferrous alloys suited for permanent mold castings, but this may not apply in reference to shock resistance and elongation. Data on thin sections can best be used in comparison with nonferrous castings, as few of the latter made in permanent molds are cast with thick sections.

While gray iron is excellent for many permanent mold castings, the size and shapes feasible are somewhat limited, especially as only sand cores are used and they cannot be so small as metal cores useable in many nonferrous castings. Cast iron affords fairly good corrosion resistance, though subject to some red rust, and has fair bearing properties. Hard scale is said to be absent but annealing is recommended to relieve strains and to soften spots of white iron sometimes formed. Sections thinner than ⅛ in. are seldom advised.

Nonferrous Alloys

Of the nonferrous alloys cast in permanent molds, those based on aluminum are by far the most important, partly because these alloys lend themselves better to casting than some others, have good properties, are moderate in cost and light in weight. This combination is not equaled by any of the other alloys suited for casting in permanent molds.

The zinc alloys, which have gained ascendency over aluminum in die casting, are inferior in some respects, including heat resistance to aluminum in permanent mold work, and are little used except for slush and decorative castings, as noted below. Copper alloys are harder to cast and cost more than aluminum per casting. Magnesium alloys, though one-third lighter than aluminum, are considerably harder to cast and cost more per casting. Lead alloys, though easy to cast, are heavy and low in strength. Under these circumstances, it is not surprising that aluminum alloys hold the preferred position.

Aluminum Alloys. Nearly all of the high strength aluminum casting alloys can be cast in permanent molds, but the choice is generally made from those listed in Table II. Design of the casting often dictates the choice but, of course, such factors as castability, type of application, cost per lb., degree of corrosion resistance for the particular application, strength, ductility, response to heat treatment, machinability, heat resistance and other factors have to be considered in arriving at a choice in particular cases.

Most alloys are made from virgin metal but others, employing secondary metal, are entirely satisfactory for most purposes and

Table I—Properties of Gray Iron Permanent Mold Castings*

Property	Section Thickness, In.			
	½	⅞	1.2	2
Tensile Strength, Psi.	52,000	34,000	32,000	22,000
Brinell Hardness No.	197	187	180	170
Compressive Strength, Psi.	124,000	112,000	119,000	100,000
Torsion, Yield Shear, Psi.	—	23,000	19,000	20,000
Torsion, Rupture Shear, Psi.	—	44,000	42,000	36,000
Transverse Breaking Load, Lb.	606	1,665	2,670	8,200
Transverse Deflection, In.	0.178	0.166	0.238	0.240
Modulus of Rupture, Psi.	99,000	76,000	71,000	63,000
Endurance Limit, Psi.	32,000	20,000	19,500	13,500
Tensile Strength, After Heat Treatment, Psi.	82,000	50,000	39,000	32,000
Growth, % Increase in Volume per Cycle	0.133	0.170	0.180	0.330

* *According to Edward C. Hoenicke, Foundry Div., Eaton Mfg. Co.*

are likely to be chosen in such cases if cost is thereby lowered. Table II gives composition and properties and indicates the characteristics and uses for which each aluminum alloy is best suited.

Many of the aluminum alloys are improved by heat treatment, and these alloys usually are heat treated before the castings are used. Although heat treatment adds somewhat to cost, this cost can be offset in some cases by employing thinner sections because of increased strength through heat treatment.

Many aluminum permanent mold castings are used with no applied finish, especially as appearance is good and corrosion resistance is generally rated as good. Many castings are polished and hold their luster for long periods under normal indoor exposures. Anodizing is readily done on most alloys, and the anodic coating increases wear resistance and can be attractively colored. Most types of organic finishes are readily applied and can be baked on. Plating is considered difficult and has not gained wide use, but recent developments in plating on aluminum may greatly extend its utility.

Magnesium alloys have the advantage of being lightest in weight and easiest to machine of all alloys suited for permanent mold casting. They are considered rather hard to cast and are employed, as a rule, only where weight savings are of sufficient advantage to offset the higher cost as compared with aluminum (as in certain castings for aircraft). High shrinkage and hot shortness make it difficult to avoid cracking of castings of some shapes in the mold.

Table III gives data on three magnesium alloys as cast and as heat treated. Although corrosion resistance is sometimes classed as "good," this is true only of castings that have been chrome nickled or given a dichro-

Table II—Composition, Properties, Characteristics and Uses of Aluminum Alloys for Permanent Mold Castings

Alloy No. or Designation	Nominal Composition % (Remainder Al)		Condition*	Ultimate Tensile Strength, Psi.	Elongation, % in 2 In.	Brinell Hardness No. (500 kg. Load, 10-mm. Ball)	Characteristics and Typical Applications
ASTM 9	Si Al	5 Rem.	AC —	21,000 min. (24,000 attainable)	5 min. (9 attainable)	35 min. (45 attainable)	Highly fluid, easy to cast. Well adapted for thin castings. Good corrosion resistance. Fair machinability. Dense structure good for pressure applications. Used for architectural castings, engine parts, instrument housings, covers, cooking utensils, etc. Not improved by heat treatment.
SAE 380	Cu Si Al	4-5 2-3 Rem.	SH SA SS	35,000 min. 40,000 min. 33,000 min.	5 min. 2 min. 3 min. (7 attainable)	65 min. 75 min. 60 min. (90 attainable)	Casts and machines readily. Most commonly used for sound, high-strength castings. Employed for aircraft engine parts such as pistons and cylinder heads and for other parts operating at elevated temperatures. Responds to heat treatment. Among the most used heat-treatable alloys.
SAE 322	Cu Si Mg Al	1.0-1.5 4.5-5.5 0.4-0.6 Rem.	SH SA SS —	32,000 min. 37,000 min. 34,000 min. (43 attainable)	4 min. 1.5 min. 1.0 min.	65 min. 75 min. 65 min. (90 attainable)	Casts readily, has fair to good corrosion resistance and is well suited for complicated castings having light and heavy sections. Retains strength at elevated temperatures. Produces sound leak proof castings. Used for watercooled cylinder heads for automotive engines. Responds to heat treatment. Machines readily.
SAE 323	Si Mg Al	6.5-7.5 0.2-0.4 Rem.	SH SA SS	28,000 min. 33,000 min. 29,000 min.	5 min. 3 min. 4 min.	50 min. 70 min. 55 min.	Casts readily and has better corrosion resistance than 322, to which it is similar. Machines readily. Employed where combination of strength and high corrosion resistance is needed. Responds to heat treatment.
ASTM SC1	Cu Si Al	4 5 Rem.	AC S —	23,000 min. 23,000 min. —	1 min. 2 min. —	60 min. 60 min. —	Used for same general purposes as No. 9. Has slightly higher tensile strength but is less ductile. Discolors when corrosion occurs. Does not respond to heat treatment.
SAE 33	Cu Si Zn Al	6.0-8.0 1.0-3.0 2.5 max. Rem.	AC S — —	23,000 min. 23,000 min. — —	1.0 min. 2.0 min. — —	60 min. 60 min. — —	General purpose alloy producible from secondary metal. Machines and polishes easily. Corrosion resistance fair. Used for automotive parts including water cooled cylinder heads, for washing machines and other home appliance parts.
SAE 321	Cu Si Ni Mg	0.5- 1.5 11.3-13.0 2.0- 3.0 0.7- 1.3	S — — SA	34,000 min. — (36,000 attainable) (40,000 attainable)	0 (0.5 attainable) — —	90 min. (105 attainable) — —	Casts fairly well. Has high hardness, low coefficient of expansion and good strength at high temperatures, which makes it suitable for automotive engine pistons as it resists scuffing, especially when anodized.
ASTM GZ1	Mg Zn Al	4 2 Rem.	— — —	27,000 — —	5.0 — —	60 — —	Fair casting characteristics, excellent corrosion resistance and machinability. Particularly well suited for cooking utensils.
ASTM 5	Cu Si Mg Fe	10 4 0.15-0.35 1.0	AC — — —	26,000 — — —	0 — — —	90 min. — — —	Casts readily. Retains hardness at elevated temperatures, making it suitable for sole plates of electric hand irons for which it is chiefly used.

* *AC—as cast*
SA—solution heat treated plus aging
S—stabilized only
SS—solution heat treated plus stabilizing
SH—solution heat treated

Table III—Composition and Properties of Magnesium Alloy Permanent Mold Castings

Designation	Aluminum	Manganese	Zinc	Magnesium	Characteristics
Dowmetal C AM 260	9.0	0.1	2.0	Rem.	Casts readily, good corrosion resistance. Yields maximum strength and pressure tightness. Good for highly stressed and intricate castings. Excellent machinability. Weight 0.066 lb. per cu. in.
Dowmetal H	6.0	0.2	3.0	Rem.	Suitable only for simple castings as alloy is hot short and subject to cracking.
Dowmetal G	10.0	0.1	—	Rem.	Best casting characteristics but lower in strength than Dowmetals C and H. Yields castings of good mechanical properties, leak tightness and excellent machinability. Weight 0.066 lb. per cu. in.

MECHANICAL PROPERTIES

Alloy	Condition	Tension						Compression		Hardness		Shear	Fatigue	Impact
		Tensile Strength, Psi.		Yield Strength[1], Psi.		Elongation % in 2 In.		Ultimate Strength, Psi.	Yield Strength, Psi.	Brinell 500 Kg. Load 10-mm. Ball	Rockwell E	Ultimate Stress, Psi.	Endurance Limit at 500,000,000 Cycles Psi.	Izod Ft.-Lb.
		Typical	Specified Minimum	Typical	Specified Minimum	Typical	Specified Minimum							
Dowmetal C	As Cast	24,000	20,000	16,000	10,000	2	1	55,000	14,000	65	77	18,000	13,000	1
C-HT	Heat Treated	39,000	32,000	16,000	10,000	10.5	6	60,000	14,000	63	75	20,000	14,000	4
C-HTA	Heat Treated and Aged	40,000	34,000	23,000	18,000	2.0	1	70,000	21,000	87	91	21,000	13,000	1
G	As Cast	22,000	18,000	13,000	10,000	2	1	48,000	13,000	54	65	17,000	11,500	2
G-HT	Heat Treated	33,000	29,000	12,000	10,000	8	5	50,000	12,000	52	62	19,000	12,500	4
G-HTA	Heat Treated and Aged	34,000	29,000	19,000	17,000	2	—	54,000	19,000	69	80	21,000	11,000	2
H	As Cast	27,000	24,000	14,000	10,000	5	4	45,000	12,000	50	59	18,000	11,000	3
H-HT	Heat Treated	39,000	32,000	14,000	10,000	12	7	46,000	12,000	56	68	19,000	12,000	5
H-HTA	Heat Treated and Aged	38,000	34,000	19,000	16,000	5	3	50,000	19,000	73	83	20,000	11,000	2

[1] *Determined by 0.2% offset method.*

These aluminum bronze castings were produced in alloy steel permanent molds. Three of the pieces have steel shaft inserts cast in place. Two parts still have sprues and runners attached.

mate treatment such as is commonly applied to all magnesium alloy castings. Organic finishes are applied after such treatment, but plating has not emerged as a commercial process for casting alloys.

Copper alloys of the commoner types are not sufficiently fluid to cast in permanent molds. For this reason, at least one maker of copper-base permanent mold castings uses aluminum bronze exclusively, as the aluminum content makes this alloy quite fluid. The melting point, however, is 1870 F and is so high that molds heat check rapidly, even when made (as is the practice with at least one prominent producer of this type of casting) in heat-resistant alloy steel. This steel is used without coating, except for daily spraying with Oildag, which helps to reduce oxidation and erosion but, even after checking, the die is still useable until checking becomes sufficient to prevent satisfactory ejection of castings.

Checking of the mold is less serious than in die casting, because the gravity pressure is not sufficient to force the alloy into cracks until they become quite wide, hence castings remain reasonably smooth. They are held within fairly close dimensional limits—considerably closer than in sand castings.

Aluminum Bronze Cast in Permanent Molds

Composition	Per Cent	Physical Properties
Copper	85 to 88	75,000 to 85,000 psi., ten. str.
Aluminum	10 to 11	36,000 psi. yield str.
Iron	2 to 3	17 to 26% elong. in 2 in.
		72 to 85 Rockwell B

Applications include gears with teeth cast close to size, retainers for antifriction bearings, levers, impellers and a variety of small castings, some of which have steel inserts. In general, uses are confined to castings that must be stronger than those made in aluminum-base alloys or that must have bearing properties or corrosion resistance superior to or of a different type than for aluminum alloys.

Although metal cores are used, they must be sturdy and have considerable draft, as shrinkage is high. Many molds are made in more than two pieces that are held together in a simple hand-operated machine equipped with means for pulling cores and separating the sections of the mold for removal of the casting. Castings weighing up to about 7 lb. maximum are produced. Casting rates range from about 6 to 20 per hr. per mold. The larger the casting the slower the rate, as a rule, but a crew of three men can handle up to 15 molds.

Zinc alloys are readily cast in permanent molds, and good castings result but, as die castings in zinc alloys are superior in properties and are produced more rapidly, the market for the permanent mold type is confined to a rather narrow range. Most of the castings are for decorative uses, chiefly in lamp parts, lighting fixtures, novelties or "trim items" where appearance is more important than strength.

Appearance and surface smoothness are better than are attainable in die castings, but are sometimes secured a little more readily, partly because molds are run hotter than dies and are filled in a different manner. Some shapes produced require molds that are made in several pieces. These would be too expensive if adapted to die casting. As no pressure is applied, flash at mold partings becomes less of a problem than in die castings, but the latter can have thinner sections.

A major field for zinc castings made in permanent molds is for so-called "slush" castings, which are shells that solidify against the walls of the mold. Although the mold is filled to a level equal to the depth of casting required, the mold is inverted soon after pouring and all metal remaining in molten form is poured out and reused. This makes it unnecessary to use a core for the casting as a whole, but cores, one of which is hollow for pouring, are often used at the ends of the casting. There is no positive control on wall thickness. If necessary, however, the recess formed can be undercut, producing a shape that would not be practicable if a solid one-piece core were used.

One great advantage of slush castings is that, if the mold is highly polished (as it often is), the casting usually has a correspondingly bright, smooth surface and can be plated or otherwise finished with little or no polishing or buffing.

Permanent molds cost less than casting dies and can be cast from bronze fairly close to size, often using a plaster pattern. This bronze is easy to chase and polish. No pressure is applied when molds are filled so they can be light, and only slight pressure is needed to hold parts of the mold together, usually with screw clamps. If heavy wall castings are required, say for a base that needs to be heavy, they can be cast solid or allowed to freeze longer than for ordinary slush castings.

Of the zinc alloys used, that containing 5.5% aluminum and the remainder special high grade zinc is readily slush cast with thin walls and hence is most economical in metal. But impurities (especially tin, lead and cadmium) must be kept below the very low maximum limits that apply in zinc die casting alloys; otherwise, network corrosion is likely to occur and weaken the casting, at the same time causing dimensional changes, warpage and cracking.

The zinc alloy, containing 4.75 aluminum, 0.25% copper and remainder special high grade zinc is considered better for general use, either in slush or in other permanent mold work, although not so easy to cast, especially in slush molds. Properties are superior to those of the alloy without copper, and service life is greater but, if walls have to be thicker, castings cost somewhat more. Composition must be closely controlled because, if aluminum content exceeds 4.75%, the undesirable eutectic composition is approached and the casting range is so narrow that slush casting becomes difficult. Decrease in aluminum content makes the alloy too sluggish for slush casting. If a baking finish is applied, neither alloy should be baked at a temperature above 375 F.

When first cast, the second alloy (that with copper content) has 28,000 psi. tensile strength and 3-ft.-lb. Charpy impact strength. Both decrease, however, with aging, especially in moist atmospheres at elevated temperature. The copper-free alloy has, when first cast, 25,000 psi. tensile strength and only 1-ft.-lb. Charpy impact strength. This alloy becomes much weaker in prolonged aging.

Lead alloys can also be slush cast with very smooth, lustrous surfaces and in thin sections. As strength is low and castings are likely to weigh and cost more than for zinc alloy castings, applications are not extensive. There is some use in lighting fixtures, lamp parts, and other decorative products and novelties. Corrosion resistance is high but the castings are comparatively soft and are subject to cold flow. A typical alloy containing 13 antimony, 1 tin, 0.5 arsenic, 0.1% copper and remainder lead is recommended for slush casting. This alloy has excellent corrosion resistance. For good casting qualities, impurities must be avoided as even small quantities of impurities impair casting quality. "C.T." metal containing 85 to 87 lead, 0.65 tin, 12.5 antimony and 0.65% max. arsenic is often used for making lead slush castings for ornamental use.

Permanent mold castings other than slush castings in lead alloy are extensively used, especially as parts for lead storage batteries. The metal for storage battery grids contains 4 to 12% antimony, but for thin light grids, antimony (which imparts greater hardness and strength) should be from 9.5 to 12%. The antimony also increases fluidity and has this fluidity over a greater temperature range. 800 to 850 F is the proper temperature for the 9.5 to 12% antimony alloy. Molds are commonly

heated to 350 to 450 F and are coated with carbon. Some expansion bolt shields and some other small castings are made in permanent molds, particularly where a soft metal is needed, high density is wanted, or high resistance to corrosion is required. The number of such applications is limited and, if quantities are large, die casting in the same or a similar alloy may prove faster and be more economical. The low melting point of lead makes for long mold life and inexpensive molds can be used. Castings should not be exposed to temperatures above 300 F.

Tin alloys are well adapted for casting in permanent molds made from bronze or rubber. Because the metal is expensive, and sometimes is in short supply, the castings are usually either quite small or are employed for decorative or other uses in which appearance, high corrosion resistance, color or some related factor warrants the high metal cost. When tin has been available for decorative applications, it has seen extensive use in jewelry and hollow ware castings.

Application of tin alloys for bearings has been extensive and continues in large volume, but in such cases the bearing cap or ring usually constitutes the outer portion of the mold to which the tin alloy is permanently bonded, and this application is outside the field here considered. Slush casting is easily done and hollow ware often has been produced in such molds. Low melting point and freedom from attack on the mold surface are favorable factors in casting; adverse factors are that the alloys are rather soft, subject to cold flow, and low in mechanical properties. Copper and antimony are the common alloying elements. Antimony increases hardness.

For permanent mold work, especially the decorative type, Britannia metal (also called pewter) is commonly used. This alloy generally contains 4 to 7 antimony and 1 to 2% copper, the remainder being tin. Castings in this alloy take a high polish approximating that of silver but are subject to tarnishing. Cheaper alloys in which considerable lead displaces some of the tin can be cast rather easily. However, lead imparts a duller luster to the castings and they are not recommended for use in contact with food or beverages as are lead-free castings. Close dimensional limits can be held.

Dimensional Tolerances

As with other forms of castings, the practical dimensional tolerances vary somewhat with the alloy used, as well as with the particular dimension in question. In general, the higher the melting point of the alloy and the greater the shrinkage, the harder it is to hold close dimensions. Those measured across a mold parting or between a point in the mold and a movable core usually require several thousandths of an in. more tolerance than do dimensions between points where there is no relative motion (for aluminum, ± 1/64 in. up to 1 in. plus 0.002 in. for each additional in.). Where measurement is affected by relative motion between mold parts, allowance must be made for clearances, wear, and for such variations as might be caused by differences in locking pressure or by bits of flash that may interfere occasionally with making close fits between die sections. Mold warpage under repeated heating and cooling also affects dimensions as do variations in the thickness of coating applied to molds. If sand cores are used, allowances have to be made for variations in the dimensions of the core itself as well as for any variations between the core and the metal "prints" or other locating means.

One prominent maker of aluminum permanent mold castings indicates that tolerances, as cast, commonly range from 0.010 to 0.050 in. but may be less or greater, depending upon design, size and alloy used and where the measurement is taken. Close tolerances should never be set without consulting a caster and should never be closer than is essential or than is held on mating parts.

It is commonly true that dimensional variations in permanent mold castings are less than for sand castings but greater than for die castings. If sand cores are used, however, the dimensions that they affect may be no closer than if the cores were used in sand molds, except that it may be possible in some cases to insure less shifting of cores than in sand molds.

Sufficient draft must be provided, of course, to free the casting from the mold and from any metal cores that may be used. The greater the shrinkage, the greater the draft should be, unless the shape of the casting is such that shrinkage causes the casting to pull away from mold walls without locking on projections or in recesses, or unless particular conditions make it necessary to remove the casting or to pull cores before shrinkage is practically complete.

In some cases, with aluminum, the minimum draft or sides of castings is set at 2 deg. on each side, but there are cases where 3 deg. is necessary and also where no draft is needed. In recesses, formed by cores or projections, 2 deg. on a side is sometimes set as a minimum and 5 deg. as desirable. It is well to allow even more draft unless this will unduly increase the amount of machining needed. L. F. Swoboda gives the following data for aluminum and magnesium: minimum diameter of cores, ¼ in. Cores supported from one end should be limited in length to 10 diameters. Minimum wall thickness approximates ⅛ in. for 3 in. or less, 5/32 in. for 3 to 6 in., and 3/16 in. for distances over 6 in.

If the alloy used is hot short, cracking is more likely to result unless shrinkage stresses can be kept within bounds by care in casting design and in mold design or by ejection before shrinkage becomes excessive. As molds commonly run hotter than for die casting and also often have a refractory lining, the cooling rate is slower than for die casting; hence, the time during which ejection can be effected without injury to the casting may be longer. On the other hand, molds are rarely opened as rapidly as casting dies can be and ejection commonly takes more time.

Since aluminum has high shrinkage and a moderately high melting point, it is likely that tolerances held on aluminum permanent mold castings can be equalled in any other type of alloy except, perhaps, on magnesium (which has nearly the same melting point) and on gray iron which, of course, has a much higher melting point.

The safest rule to follow, especially where close as-cast dimensions must be held, is to consult the caster while the design is being developed. If he considers the proposed limits too close, he may either refuse the job or insist upon changes or upon machining, at whatever extra expense may be incurred. Machining can be done, of course, as close as on any casting in the same alloy.

Allowances for finish again depend upon the size of casting, the alloy used, and where machining must be done. For aluminum, the range is usually from 1/32 to ⅛ in., but in many cases 1/32 to 1/16 in. is sufficient. Swoboda gives the following as allowances for machining on aluminum: castings up to 10 in. long, 1/32 in. minimum, 3/64 in. desirable; castings over 10 in. long, 3/64 in. minimum, 1/16 in. desirable; surfaces formed by cores, 1/16 in. minimum.

Characters at least 3/16 in. in height (parallel to face) are recommended as the smallest practicable for letters and numbers, which are preferably raised above the surrounding surface of the casting. This is especially true in the use of aluminum and higher melting alloys, as any smaller size will not remain legible for long after the mold is put into use. Small projections on molds wear rapidly, and even small recesses suffer considerable wear when casting aluminum and higher melting alloys. Conversely, for the lower melting alloys based on zinc or on lead, wear is less rapid and finer details can be held.

Since there is some interrelation between tolerances, finish allowances, and locating or gaging points, such points should be clearly indicated on drawings and should be spaced as far apart as conditions permit. If both supplier and purchaser use the same points, rejects can be minimized with savings for both parties.

Production Conditions Affecting Design

All castings should be designed with due regard to the conditions that have to be met in production. The better acquainted the designer is with these conditions, the better equipped he is to prepare designs capable of production at minimum cost consistent with meeting other requirements. Permanent mold castings are far from being an exception to this rule. In fact, no design should be completely developed without securing and following, as far as practical, experience based on intimate con-

tact with production possibilities and limitations. Even a designer familiar with fundamentals of production may fail to take advantage of possible production economies unless he consults an expert in constant touch with the production of permanent mold castings.

Even though such consultation may result in recommendations that cannot be followed in all details, it can certainly eliminate needless departure from good practice and is likely to result both in securing better castings and in lower costs. It may even be necessary to make minor changes after molds are constructed to eliminate unforeseen difficulties, but reasonable cooperation between designer and foundry is almost certain to benefit all concerned. Such cooperation has made it possible to convert many sand castings to permanent mold castings with remarkable savings in over-all costs as well as in obtaining greatly superior castings.

Most foundries find it advantageous to limit the number of alloys used because it complicates metallurgical and other problems to do otherwise. Changes to unfamiliar alloys often affect the technique required and can necessitate considerable experimental work and retraining of casters to gain desired results. For these reasons, it is best not to insist upon using alloys new to the foundry chosen unless it is certain that any advantage gained is commensurate with such cost increases as are incurred. Often, it is better to seek a foundry experienced in using a particular uncommon alloy, if it must be chosen, than to insist upon its use by a foundry that must alter current methods if an alloy new in the experience of this foundry is to be cast.

Nearly all foundries making permanent mold castings use only one base metal because each metal necessitates a particular technique and type of mold construction. A few handle two similar metals (such as aluminum and magnesium) but, except when this is done regularly, it is best to seek out a specialist in the type of metal chosen, as he usually knows its problems and should be best equipped to handle this type of metal efficiently.

Unless the expense and uncertainties of experimental work are to be faced, it is best to keep within size and weight limits that are known to be feasible or that producers are prepared to supply at an acceptable price. It is well to make sure also that production rates will be such as to keep step with the purchaser's needs. If these exceed the output attainable from a single mold, more than one mold may be needed. For small castings, more than one cavity sometimes can be used in a single mold.

If cores are required, the type to be used must be considered, as well as the means for withdrawal from the casting. Where sand cores are essential, boxes for making them have to be provided, and means for locating the sand core or cores in the mold and for removing the cores after casting are necessary.

Although the designer of the casting usually need not design the mold, he often can profit by knowing how it must be built and operated and what is necessary in the way of coating, chills, gates, risers, vents, etc., as these sometimes affect the quality of casting and influence the cost of machining and finishing. For example, some molds have to be coated and others do not and this may affect tolerances, degree of smoothness, and number or character of finishing operations, rate of casting, and other factors.

As molds wear, some dimensions of castings are likely to be affected, and allowance for this may have to be made in machining fixtures and jigs, which are often designed by the purchaser. If the castings must be heat treated, the cost of this and arrangements for having it done demand consideration.

Since permanent mold castings usually are stronger and have less porosity than sand castings, they often can be made lighter in weight without sacrifice in strength. Moreover, smaller allowances need be made for machining, which often result in marked savings in metal with considerable reduction in metal costs that, as a rule, are prime considerations in design.

The simpler the casting, the simpler the mold can be. Complex castings often make it necessary to build the mold in more than two pieces, and to use more cores, or cores made in more than one piece or in sand. This may be fully justified by advantages gained, but the designer should make sure that such advantages warrant whatever extra expense is involved and that some simpler and less expensive alternative yielding equal or greater advantages at lower cost is not overlooked.

When a hollow part suited for slush casting is needed and the alloys practicable for such casting meet requirements, this type of casting deserves attention, as it is adaptable to thin wall parts that can be made without cores involving undercuts, and at moderate cost.

Some makers of metal products have found it possible to produce their own permanent mold castings or at least a portion of their requirements. It is worth noting that, as the process is a relatively clean one and usually does not involve handling sand, it can be done in a machine shop or adjacent room. Experience in casting and in mold design must be gained, and the equipment should be used enough to warrant the installation and carrying charges. In most cases, however, permanent mold castings are purchased from specialists in such work, as this is commonly most convenient and economical.

Design Rules

Nearly all rules for design require some qualification and are subject to exceptions. All design involves compromises but the common requirement is to obtain a given result at minimum cost. The following rules are intended to serve as a guide and as an aid toward keeping costs at a minimum. Many of the rules cannot be followed in specific cases partly because it is often expedient to sacrifice something in economy to attain benefits in other directions considered more important.

Thus, the rules can be regarded in the light of recommended practice which can be expected to help keep costs within bounds. By checking a given design against the rules and avoiding violations (except where there is adequate reason for doing otherwise), economies that would be sacrificed if this course is not followed can be attained.

1. *Keep size at the minimum consistent with other needs.* In general, the larger the casting, the more it costs and the higher mold costs will be. Larger castings are harder and slower to make and, as they require more metal and larger molds, costs for these are increased. On the other hand, it often happens that a large casting made in one piece costs less than two or more smaller castings machined and assembled into a structure serving the same purpose as a single large casting. In that event, the larger casting may prove the better alternative.

2. *Strive to attain uniformity in section thickness but, where variations in thickness are considered necessary or yield important benefits, see that the transition from thick to thin is gradual rather than abrupt.* This rule applies to all types of castings. Where sections vary the thinner ones freeze first and severe shrinkage stresses are set up when adjacent heavier sections freeze. In general, shrinkage stresses are highest where abrupt changes in thickness occur. Gradual changes in thickness help to reduce such stress concentration. Fillets also help to avoid stress concentrations and often can be used to advantage in making gradual changes in section.

3. *Avoid thick sections isolated by thin ones unless the thick section can be so located as to be readily filled.* This rule also applies to all types of castings and often profoundly affects mold design. In permanent mold work, the thick section is kept at a mold parting, where it is filled directly through a gate. A riser may also be needed. Thick sections will not fill out if fed only through thin sections, as the latter freeze first; but if the feed is at the thick section, metal will flow through it to the thinner sections and continue until both the thin and thick sections are filled.

4. *Keep all sections as thin as is compatible with adequate strength and stiffness and with reasonable ease in casting.* This not only insures that no excess of metal is used but helps to accelerate casting rates, as the casting cools more quickly when thin and can be removed from the mold sooner. In addition, die life may be increased, especially with alloys that melt at high temperature. On the other hand, if walls are so thin that casting becomes difficult or too critical, so that rejects are excessive, costs go up and advantages otherwise attained are lost. This makes it wise to consult the foundry and to avoid sections so thin that undue casting difficulties arise.

Sometimes it is expedient to plan on using sections somewhat thinner than the foundry advises with a view to trying the mold before the final thickness is set. If sections then prove too thin to cast economically, the mold can be altered accordingly. Extra costs for this procedure should be expected by the purchaser but, if the thin sections prove feasible, he may find that castings will cost less than if thicker walls were used. If the mold is made to cast walls thicker than needed, it is difficult or impossible to make the walls thinner subsequently without constructing a new mold.

Shown here are a variety of magnesium alloy parts produced as permanent mold castings.

In slush casting, there is no positive control on section thickness except where a metal core is used. It may be necessary, however, to specify a certain minimum thickness to insure adequate strength and stiffness. The maximum thickness also can be specified, especially if a maximum weight has to be set.

5. *Avoid complex structures unless assured that casting will be feasible and not involve undue expenses for molds, cores and casting difficulties.* Although reasonably complex castings can be made in permanent molds and such castings have advantages in avoiding the machining and assembly of extra parts, these benefits might be canceled out if casting becomes too difficult, if rejects run high, or if mold and core costs become excessive. Each factor affecting costs deserves study and analysis if optimum results are to be secured. Without such study and consideration of possible alternatives, even the most expert designer can go astray. Closest cooperation with the caster is advisable, as only he can assess each factor and avoid those difficulties that mean the difference between practical success and failure.

6. *Make full use of coring possibilities where assured that coring benefits will compensate fully for whatever cost increase is involved.* As precise coring can be done and proper coring saves metal, helps to avoid undue metal concentration, and generally saves machining, such important advantages should not be sacrificed without good reason. On the other hand, the cost of cores and of means and time needed to operate them demand due consideration. If cores are expensive and satisfactory results are attainable at lower cost without their use, their elimination is in order.

Although cores down to ⅛ in. or less in diameter are possible in some cases, especially with castings of low melting point, if core length is not too great, it is often cheaper or more satisfactory or both to drill small holes than to core them. Cores for aluminum and magnesium should conform to tolerance recommendations. Much depends upon the location and length of the core and upon what is necessary to force the casting off the core or to pull the core from the casting. Erosion and mechanical wear on cores also has to be considered and is highest with alloys cast at high temperatures. The cost of core pulling mechanisms also requires consideration. Metal cores that are long in reference to diameter should not be specified unless the caster gives assurance that the application is advisable.

Although the use of split or multi-piece metal cores is feasible in some types of permanent mold casting, the use of such cores slows the casting cycle and usually adds considerable both to the cost of the core and to that for flash removal. Unless these increases in cost are offset by savings in metal and in machine work or in providing castings better suited for the particular application, the use of split cores is not recommended.

Sand cores alone are practicable in gray iron castings and sometimes are necessary in other alloys. When sand cores are needed, core boxes must be built and cores made for each casting at costs that must be considered. Such costs are often justified but should be required only when the benefits secured are commensurate with the costs. In some cases it is better to alter a design to permit the use of metal rather than sand cores, but in many cases it is necessary to compare costs and weigh relative advantages of both metal and sand cores to be certain that the better alternative is chosen.

As each independent core or core part that requires separate handling adds that much to the time per cycle, it is expedient to limit the number of cores to that known to be economical or to so arrange cores that operation of two or more at a time is readily accomplished. It is seldom possible (as in die casting) to arrange for automatic core operation.

As slush castings can be made hollow, even where undercuts are involved, without the use of cores or with only small inexpensive cores, the use of such castings deserves attention where alloys of low melting point meet requirements.

7. *Make sure that the part to be cast is so shaped that it can be cast readily in a permanent mold.* This necessitates giving due attention to the location of mold partings, runners, and gates as well as to risers, if the latter are needed. Although the designer of the casting seldom designs the mold, he can profit by trying to visualize the casting in the mold, and how the mold is to be filled and the casting removed along with metal that fills the sprue hole, runners, gates and risers. When the designer is not familiar with such details, the help of a competent caster should be sought.

Unless the mold can be filled without undue turbulence and the casting is capable of progressive solidification, there is likely to be much difficulty in producing castings that are sound and free from cracks or surface blemishes. If metal cores cannot be pulled readily or if excessive pressure is needed to eject the casting, the production of acceptable castings may not be feasible or costs may become prohibitive. These things must have attention sooner or later and, unless given proper study during the initial design of the casting, it may be necessary to alter the design later to adapt the casting to practical production in a permanent mold on a commercial scale.

All sections must be thick enough to fill out and to afford adequate strength and stiffness. Castability usually depends also upon the position the casting is to take in the mold, where cores must be pulled, how the mold must be parted, and other factors which should be discussed with foundrymen familiar with casting the particular type of alloy chosen.

In most permanent mold casting, the mold remains fixed during pouring, but in making slush castings and some solid castings in low melting alloys, the mold is rocked slowly during and subsequent to filling. Such matters may or may not affect the design of the casting, but they do greatly affect the design of the mold and casting quality and, if casting design is such that satisfactory castings cannot be produced on an economic basis, the design of the casting may have to be altered. These and related considerations make it most important that the designer work in close cooperation with the foundryman when developing a new design of casting.

8. *Employ ribs where necessary to stiffen walls or add strength but make sure that ribs are so proportioned as not to be excessively stressed and are so placed that production of castings is not handicapped.* By the judicious use of ribs, thinner sections than would otherwise be necessary often can be employed. This tends to lower the weight and cost of castings and commonly increases stiffness and strength, if correct proportions are used. On the other hand, ribs tend to cool rapidly and set up shrinkage stresses sufficient to cause cracking unless proper care in design is exercised.

In general, rib thickness should approximate that of the adjacent thin walls they are designed to stiffen. If connected to a boss or to other sections that are considerably thicker, there should be generous fillets where the ribs join the boss and as gradual a blending of thick to thin as conditions permit. Outer edges of ribs should be rounded but, for aluminum and magnesium, at least, a blunt edge is sometimes favored over one having a radius equal to half the thickness. Where ribs join thin sections, fillets should be small enough so as not to substantially increase the section at the junction of rib and wall.

In no case should ribs form undercuts or tend to lock the casting in the mold in such a way that cracking from shrinkage is likely to occur. Consultation with the caster is advised, especially when there is the least uncertainty about the effect of ribs on shrinkage or upon removal of the casting from the mold.

Ribs should never be so thin or so deep that they do not fill out properly, of course, and should not be depended upon as channels through which molten metal is expected to flow to fill thick sections not fed through other channels.

9. *Design the casting so that, consistent with other requirements, a mold having a minimum number of component parts can be used.* When this is done, mold cost is apt to be lowered and mold operation simplified. Each extra mold part involves joints that, in general, require extra machine work as well as extra handling of mold components in producing castings.

On the other hand, extra mold parts often make it possible to cast shapes that could not be cast otherwise (and that it would not be advisable to die cast) and sometimes enable the use of extra gates and risers that help to fill out a casting which could not be produced readily, if at all. All production involves some compromises and in this, as in other cases, the

objective should be to meet essential requirements without undue cost.

10. *Provide ample fillets at wall junctions but, where fillets of large radius are used, see that both faces follow the same contour to avoid unnecessary metal concentrations.* Sharp interior corners weaken a casting and are likely to make castings more difficult to produce. Such sharp interior corners frequently result also in stress concentrations that cause cracking in the mold or fractures in service. Proper fillets, on the other hand, tend to avoid stress concentrations and to make castings stronger and stiffer.

If a large fillet is used at an inside corner without a similar rounding at the opposite face or in such a way that there is undue metal concentration at the junction, this can result in a "hot spot" and delayed cooling with unequal stresses and possible porosity in the thick area.

Sharp interior corners can be produced only by sharp exterior edges of the die, and such sharp edges are likely to crack or be eroded if the metal cast has a high melting point. Such trouble is avoided or minimized when proper filleting is specified. Even a fillet of small radius is better than none.

11. *See that side walls and holes produced by metal cores have adequate draft to facilitate removal of castings from the mold and core removal.* Unless adequate draft is provided, removal of the casting may be so difficult as to result in cracking or distortion of the casting in addition to excessive wear on mold and cores. Such trouble is obviated, as a rule, if sufficient draft is provided.

The minimum amount of draft required varies with the alloy used and with the size and shape of casting and mold. For aluminum and magnesium, which have high shrinkage, 2 to 3 deg. minimum draft on side walls and about 5 deg. on cores is usually sufficient, but the precise minimum should be checked with the caster before being finally set. On low-melting alloys, somewhat less draft is sufficient. Drafts greater than the minimum are often advantageous unless they tend to increase the amount of machining needed or add significantly to the weight of the casting.

12. *Avoid undercuts unless the benefits derived are known to offset whatever cost increase may be incurred.* When feasible at all, undercuts commonly add considerably to mold or core costs, or both, and often tend to lengthen the casting cycle; therefore, it is a common recommendation that undercuts be avoided. On the other hand, both casters and designers know that undercuts sometimes are necessary or desirable, as then some shapes of castings become practicable in permanent molds when they would have to be sand cast otherwise.

Some castings have to be made in molds having three or more pieces because, if fewer pieces were used, there would be undercuts that would make ejection impossible. The extra parts increase mold and handling costs but often the added costs are justified by benefits derived.

If a cored recess involves undercuts, the core commonly must be made in more than one piece, if it is metal, or must be of dry sand. There are corresponding disadvantages, as already explained, but these are often accompanied by compensating gains, such as a more favorable shape or avoidance of sections thicker than necessary. In each case, it is expedient to consider the alternatives and to choose that yielding the better overall benefits. It is best to make sure, however, that casting is not rendered so difficult that the cost per piece becomes excessive.

Where split metal cores must be used, it is best to allow ample openings for the removal of the core parts. If sand cores are used, costs for their production and removal should not be overlooked. Where the alloy chosen is one suited for slush casting, internal undercuts can be made without any core.

13. *Where inserts cast in place appear to promise net benefits, make sure that their application is feasible and not excessive in cost.* Some inserts, usually of metal different from that being cast, can be cast in place without undue cost and with considerable net benefit. This is done especially with aluminum, bronze and zinc alloys and may be advisable in certain other cases. The insert, however, should provide some property or benefit not otherwise secured and must, if cast in place, be of such a nature that its application is practical from the foundryman's standpoint. This should be ascertained by consultation with the foundryman before an insert is specified.

In general, the customer supplies the insert and must see that it meets dimensional and other requirements. These include ability to fit and be held in position by the mold and sufficiently secure anchorage in the casting not to come loose in service. Usually, inserts must be free of oxide coatings and sometimes they must be heated before being placed in the mold, otherwise they act as chills and may prevent the casting from filling out.

Some inserts can be applied more cheaply or to better advantage after casting but, when cast in place, should be grooved, drilled, knurled or otherwise provided with means for proper anchorage. There should be enough metal cast around the insert to prevent cracking of the casting when it freezes and contracts around the insert.

14. *Never specify dimensional tolerances closer than are essential or than are held on mating parts.* Although dimensions can be held within closer limits than for sand castings, costs may be needlessly increased by specifying closer dimensional limits than are essential or than are held on mating parts. Tolerances should allow sufficient metal for machining where as-cast dimensions do not come within the limits set. If the caster must machine the casting to hold unusually close limits, extra charges for so doing should be expected.

Except where a fit or a close clearance is essential, the specification or drawing should allow for whatever variations may be expected in normal permanent mold casting work. To do otherwise can add considerably to cost with no compensating benefit whatever.

15. *Design the casting so that, subject to attainment of other desired objectives, flash removal costs will be minimized.* This can be accomplished by using shapes in which the number of mold partings is minimized and by bringing necessary partings where machining is necessary anyway or where, if needed only for flash removal, the machining can be done with only slight cost. This is a matter to be discussed with the caster, especially if there is question as to where partings will come. If cores are used and give rise to extra flash, the effect of its removal on cost should have due attention.

In general, permanent mold castings have less flash than die castings, as there is little pressure to force molten metal out of partings, and such flash is commonly removed by the caster. There is left a parting line at each mold joint and this line remains unless the surface is machined, ground or polished. The latter operations are rarely done by the caster unless he is paid extra for doing them except that he may do a very rough grinding as a part of "snagging" where a gate is cut off.

Except for decorative castings, flash lines are of little concern unless they affect a fit with a mating part. Where a machined fit is necessary, flash lines are cut off anyway when machining is done. On some decorative castings, including many made in slush molds, the flash line is brought on a convex bead or on a surface of rotation where a light cut, grind or polish takes the line off at slight or no extra expense. Many slush castings are polished anyway as a preliminary to plating. In other cases, some low relief which is a part of the decorative design, masks the parting line sufficiently to make its removal unnecessary.

16. *Where a gear, cam, ratchet or similar part (that, unless cast, must be cut at high cost from wrought stock) is needed, provide for casting is separately or as an integral part of some other casting.* Often, castings of this nature are produced in permanent molds so close to size and shape that little or no machining is needed. Sometimes, on such parts, a light cut made by a simple shaving die, at nearly negligible cost, gives an excellent machine finish, say to gear teeth, yet holds critical dimensions to close limits. This is possible because contours can be shaped close to size by the mold, hence very little metal need be shaved off in the machining process.

Although the possibilities in this direction do not quite match those in die casting, they are still of considerable importance, at least in the nonferrous alloys, and are put to good use by designers who take full advantage of permanent molding economies. Not infrequently, a gear, cam or similar part can be cast integrally with some actuating or driven element, thus avoiding extra machining and assembly operations that would be necessary otherwise. Where needed, a steel shaft often is cast in place to support and turn with the gear or cam or with the assembly of which they are parts.

17. *Where appearance is significant, see that external contours are pleasing and in keeping with mating parts.* This is of importance in the case of housings and other elements exposed to view, especially those used for consumer products or where eye appeal contributes to salability. In general, simple geometric contours are preferred and lines should blend with those of other exposed and adjacent elements of the assembly. Modern trends call for so-called "streamlined" appearance, that is, for shapes with a minimum of projections and that make the casting appear well suited for the function it performs.

Although some designers frown upon decorative detail, others employ low relief effectively, especially on slush castings for lamps, lighting fixtures and the like. Fluted columns with turned bases and capitals are among the castings with low relief in extensive use.

Many industrial designers engaged in "styling" various products are called upon to assist engineers who lack experience in such work. Where the engineer is not expert in design from an appearance standpoint, assistance obtained by styling specialists is often most helpful in creating the eye appeal needed to promote ready sale.

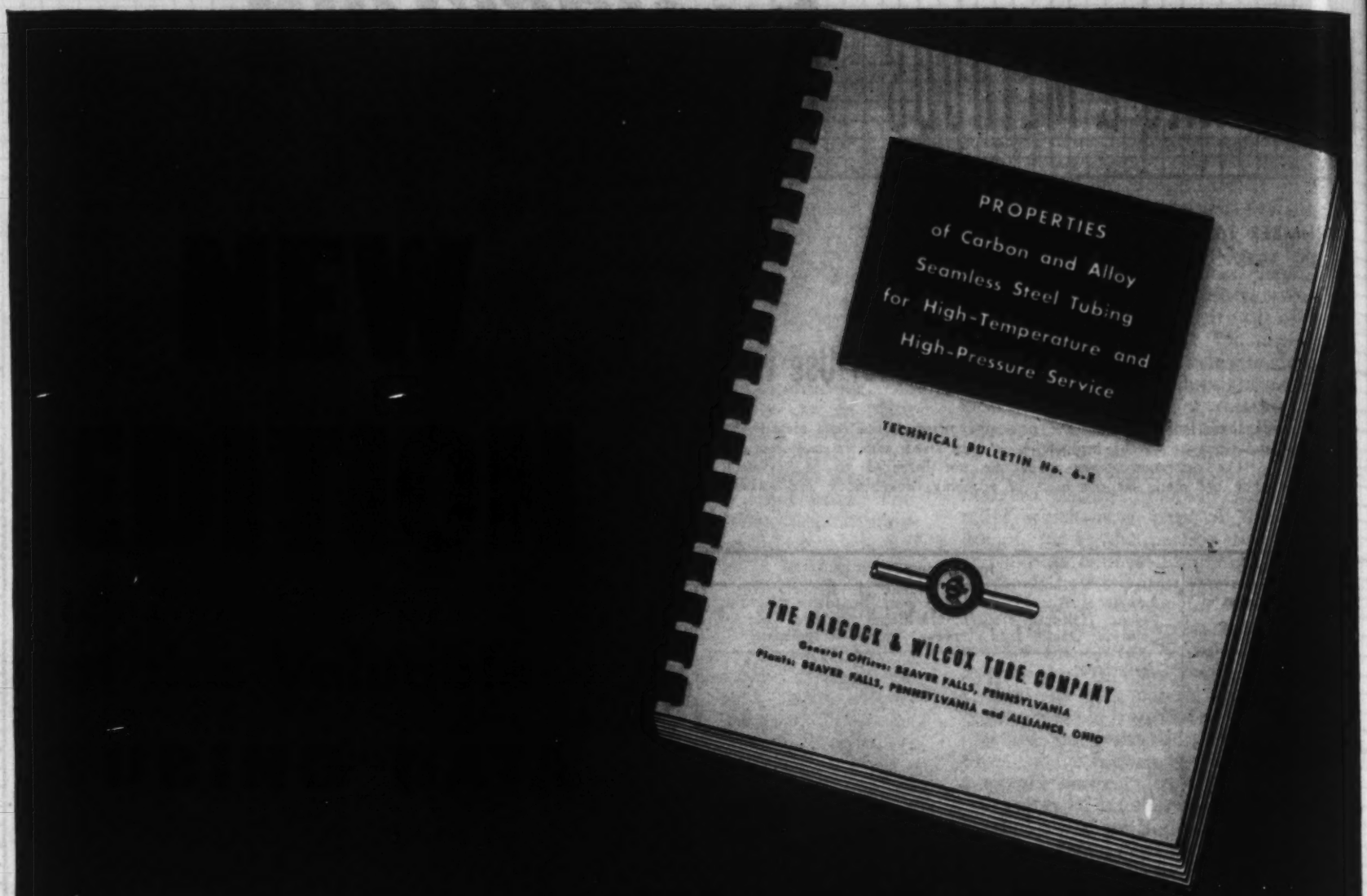
NUMBER 163
July, 1948

Metals for Use with Highly Corrosive Media

Listed on these two pages are the principal corrosion resistant metals and recommendations as to the media they can be used with in manufactured products. The recommendations made are not intended to be complete. Rather they are made on the basis of economy, availability and relative ease of fabrication in cast forms. Where a metal is listed as impervious to a given corrosive agent, it is obvious that the metal is also capable of withstanding intermittent contact. Therefore, duplicate listings have not been made.

Material	Impervious To	Highly Resistant To
Aluminum	Acetylene, Air, Ammonia, Argon, Butadiene, Butane, Freon, Helium, Hexane, Hydrogen Sulfide, Methyl Chloride, Oxalic Acid, Oxygen, Ozone, Propylene	Acetic Acid, Acetic Anhydride, Gelatin, Lacquers, Sulfur
Brass	Diethylene	Acetaldehyde, Acetone, Acetylene, Air, Alcohol, Amyl Chloride, Argon, Arochlor, Benzaldehyde, Blood, Butadiene, Butane, Butylene, Carbon Tetrachloride, Carbonic Acid, Chloroform, Cyclopropane, Embalming Fluid, Ethane Gas, Ether, Ethyl Chloride, Ethylene Chlorohydrin, Ethylene Glycol, Ethylene Oxide, Formaldehyde, Freon, Gasoline, Glycol, Helium, Hexane, Hydrogen, Ketones, Latex, Lubricating Oils, Nitro Ethane, Nitrogen, Nitro Propane, Nitrous Oxide, Octane Iso, Oxygen, Ozone, Paraffin, Pentane, Potato Glucose Solution, Propylene, Propylene Dichloride, Propylene Glycol, Sulfur Di- and Trioxide, Tannic Acid, Turbine Oil, Urea, Vinyl Acetate, Water
Bronze	Calcium Chloride (salt), Sodium Chloride, Sea Water	Beer and Beer Mash, Benzol, Clay Slurries, Fatty Acid, Fish Oils, Glycerine, Kerosene, Lactic Acid, Methyl Chloride, Molasses, Naphtha, Pyroligneous Acid, Starch, Styrene, Waste Sulfite Liquor (zinc-free bronze), Trichlorethylene, Vegetable Oils, Whiskey, Wine, Wort, Zein
Duriron	Alum (Alum Sulfate)	Calcium Hypochlorite, Chloroacetic Acid
Hastelloy "A"	Phenol	—
"B"	Ammonium Chloride, Ammonium Fluoride, Boric Acid, Copper Chloride, Hydrofluoric Acid, Hydrofluosilicic Acid, Hydrogen Chloride Gas, Phenol, Sodium Pyrophosphate	—
"C"	Acetic Acid (glacial), Alum, Aluminum Chloride, Aluminum Fluoride, Ammonium Chloride, Ammonium Fluoride, Ammonium Sulfate, Boric Acid, Calcium Bisulfite, Calcium Hypochlorite, Chloral, Chlorine (pure), Chlorine Dioxide, Chlorosulphonic Acid, Copper Chloride, Ferric Chloride, Ferric Sulfate, Ferrous Sulfate, Hydrochloric Acid, Hydrofluoric Acid, Hydrofluosilicic Acid, Hydrogen Fluoride Gas, Iodine, Phenol, Phosphoric Acid, Sodium Hypochlorite, Spin Bath Solution, Sulfuric Acid, Sulfuric Acid (Fuming Oleum), Sulfurous Acid, Thionyl Chloride	Chromic Acid, Hydrobromic Acid
Iron	—	Acrolein, Ammonia, Ammonium Hydroxide, Ammonium Nitrate, Arochlor, Asphalt, Beet Sugar Liquors, Benzol, Black Sul. Liquor, Borax, Boric Acid, Boron Chloride, Butadiene, Butane, Butylene, Calcium Bisulfite, Calcium Hydroxide, Camphene, Carbon Bisulfide, Carbon Dioxide, Carbon Monoxide, Chlorine, Chlorine Dioxide, Chloro Ethane, Clay Slurries, Creosote, Cresols, Cresylic Acid, Cyanogen Chloride, Cyanohydrin, Cyclohexane, Cyclohexanone, Cyclopropane, Diethylene Glycol, Diphenyl, Dowtherm, Ethane Gas, Ethanolamine, Ether, Ethyl Acetate, Ethyl Acrylate, Ethyl Chloride, Ethyl Mercaptan, Ethylene Chlorohydrin, Furfural, Gasoline, Glue Glycerine, Heptane, Hydrogen Sulfide, Hydroguinone, Illuminating Gas, Kerosene, Latex, Lead Nitrate, Lime Slurries, Lithium Chloride, Magnesium Hydroxide, Magnesium Sulfate, Mercaptan, Mercury, Mesityl Oxide, Mixed (sulfuric and nitric) Acid, Molasses, Naphtha, Naphthalene, Nitro Benzine, Palmitic Acid, Phenylethylmalonic Ester, Petrolatum, Phenolic Sulfonate, Phosgene, Phosphorous (liquid), Phthalic Anhydride, Pine Gum, Potassium Chloride, Potassium Chlorate, Potassium Cyanide, Potassium Hydroxide, Potassium Permanganate, Potassium Sulfate, Propane, Rosin Emulsions, Soap, Sodium Aluminate, Sodium Carbonate, Sodium Cyanide, Sodium Dichromate, Sodium Ethylate, Sodium Glutamate, Sodium Hydroxide (0-20%), Sodium Nitrate, Sodium Phosphate, Sodium Silicate, Sodium Sulfate, Sodium Sulfide, Steam, Stearic Acid, Stoddard Solvent, Styrene, Sulfuric Acid (93-98%), Tar, Terpene Monocyclic, Thionyl Chloride, Titanium Tetrachloride, Toluene, Trichlorethylene, Turpentine, Vegetable Oils, Vinyl Chloride, Wax, Xylene, Xylenol, Zein
Lead	Tin Tetrachloride	Alum, Ammonium Chloride, Chromic Acid, Sodium Sulfite, Spin Bath Solution, Sulfuric Acid (0-93%), Sulfurous Acid
Monel	Acetic-Anhydride, Ammonium Chloride, Ammonium Fluoride, Fluorine (anhydrous), Hydrogen Fluoride Gas, Magnesium Chloride, Phenol, Potassium Hydroxide, Potassium Sulfate, Propionic, Soap, Sodium Bisulfate, Sodium Hydroxide (above 20%), Sea Water, Zinc Chloride	Hydrofluoric Acid, Iodine, Phosphoric Acid
Nickel	Chloral, Phosphorous Oxychloride, Sodium Hydroxide (above 20%), Vinyl Resin Latex	—
Phosphor Bronze	—	Ammonium Phosphate, Ammonium Sulfate, Copper, Sulfate, Ferrous Chloride, Ferrous Sulfate, Sodium Sulfite

(Continued on page 89)



147 pages of up-to-date metallurgical and application data on steel tubing for high-pressure, high-temperature services.

In this sixth edition of Technical Bulletin 6-E, B&W makes available 147 pages of the latest information on properties and uses of stainless, alloy and carbon steel tubing for high-pressure and high-temperature services in all industries. Included in this are comprehensive and authoritative reference data on newest developments in alloy tubing—results of extensive field and laboratory research —service experience with tube applications—and much additional information of value to tube users accumulated since the previous edition in 1941.

Every user of pressure tubing will find this new book helpful. So request your copy today—on your Company letterhead.

TA 14585

B&W

BABCOCK & WILCOX
SEAMLESS & WELDED TUBES
THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
PLANTS: BEAVER FALLS, PA. AND ALLIANCE, OHIO.

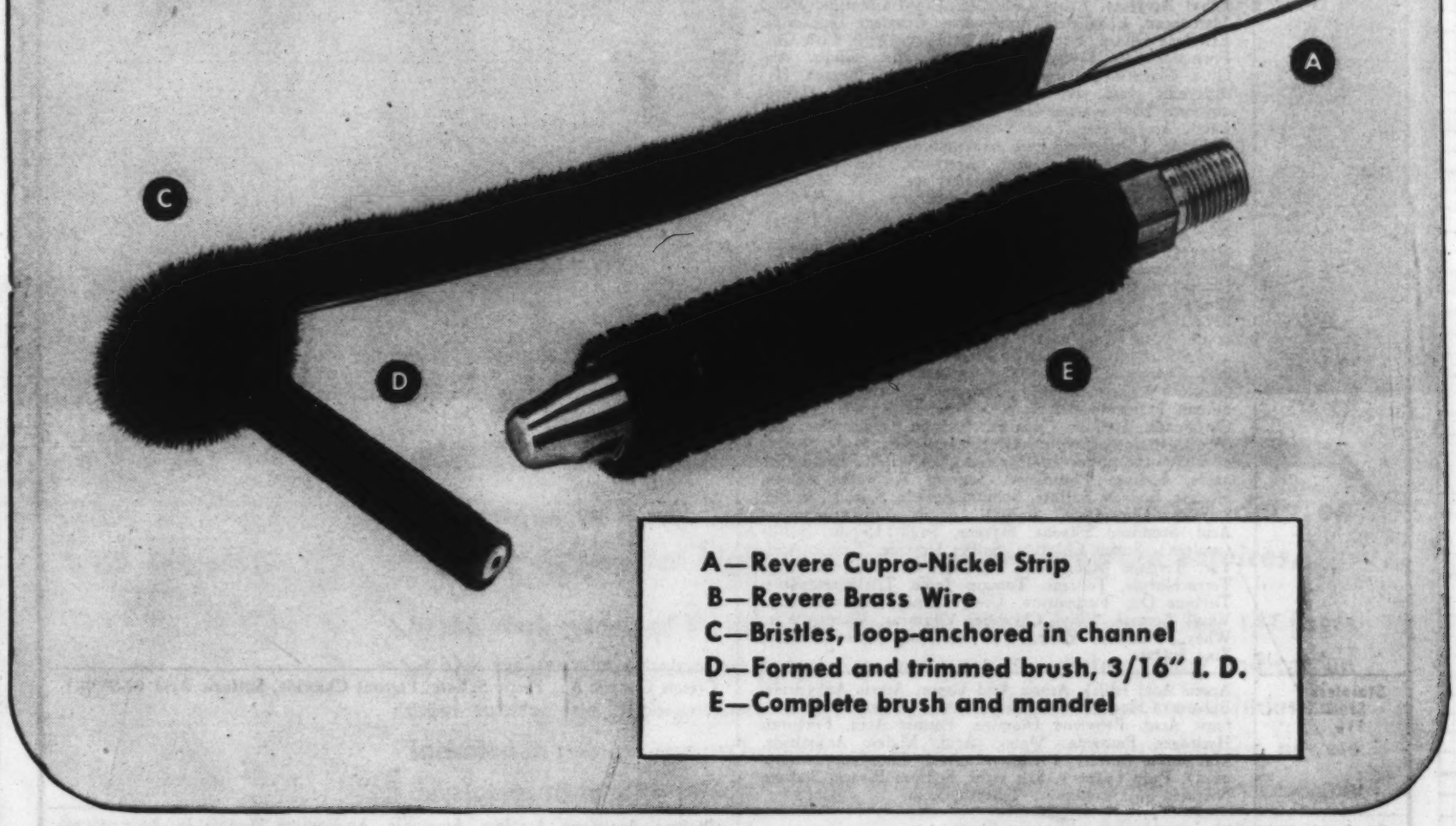
NUMBER 163, (Continued) **Metals for Use with Highly Corrosive Media**

Material	Impervious To	Highly Resistant To
Silver	—	Chlorine (pure vapor or liquid)
Stainless Steel 303	Acetaldehyde, Acetic Acid, Acetone, Acetylene, Acrolein, Air, Alcohol, Ammonia, Ammonium Fluosilicate, Ammonium Hydroxide, Ammonium Nitrate, Ammonium Phosphate, Amyl Acetate, Amyl Chloride, Aniline, Argon, Arochlor, Asphalt, Barium Hydroxide, Barium Sulfide, Beer & Beer Mash, Beet Sugar Liquors, Benzaldehyde, Benzol, Black Sul. Liquor, Blood, Borax, Boric Acid, Boron Trifluoride, Butadiene, Butane, Butylene, Calcium Hydroxide, Camphene, Carbon Bisulfide, Carbon Dioxide, Carbon Monoxide, Carbon Tetrachloride, Carbonic Acid, Chloro Ethane, Chloroform, Citric Acid, Clay Slurries, Coffee, Copper Sulfate, Creosote, Cresols Cresylic Ac., Cyanogen Chloride, Cyanohydrin, Cyclohexane, Cyclohexanone, Cyclopropane, Diethylene Glycol, Dioctyl Phthalate, Diphenyl, Dowtherm, Embalming Fluid, Ethane Gas, Ethanolamine, Ether, Ethyl Acetate, Ethyl Acrylate, Ethyl Cellulose, Ethyl Chloride, Ethyl Mercaptan, Ethylene Chlorohydrin, Ethylene Dichloride, Ethylene Glycol, Ethylene Oxide, Fatty Acid, Fish Oils, Formaldehyde, Freon, Gasoline, Gelatin, Ginger Ale, Glue, Glycerine, Glycol, Helium, Heptane, Hexane, Hydrocyanic Acid, Hydrogen, Hydrogen Sulfide, Hydroquinone, Illuminating Gas, Kerosene, Ketones, Lacquers, Lactic Acid, Latex, Lead Nitrate, Lime Slurries, Lithium Chloride, Lubricating Oils, Magnesium Hydroxide, Magnesium Sulfate, Mercaptan, Mercury, Mesityl Oxide, Methyl Chloride, Methyl Methacrylate, Milk, Molasses, Naphtha, Naphthalene, Nickel Sulfate, Nitric Acid, Nitro Benzene, Nitro Ethane, Nitrogen, Nitro Propane, Nitrous Oxide, Octane Iso, Oleic Acid, Oxalic Acid, Oxygen, Ozone, Palmitic Acid, Paraffin, Pectin, Penicillin, Pentane, Perfume, Petrolatum, Phenolic Sulfonate, Phenylamine O-Bl, Phenylthymalonic Ester, Phosgene, Phthalic Anhydride, Picric Acid, Pine Gum, Potash, Potassium Chloride, Potassium Chlorate, Potassium Cyanide, Potassium Iodide, Potassium Permanganate, Potassium Phosphate, Potato Glucose Sol., Propane, Propylene, Propylene Dichloride, Propylene Glycol, Propylene Oxide, Pyridine, Pyroligneous Acid, Rosin Emulsions, Silicon Tetrachloride, Soap, Sodium Aluminate, Sodium Carbonate, Sodium Cyanide, Sodium Dichromate, Sodium Ethylate, Sodium Glutamate, Sodium Hydroxide (0-20% and above 50%), Sodium Oleate, Sodium Peroxide, Sodium Phosphate, Sodium Resinate, Sodium Silicate, Sodium Sulfate, Sodium Sulfide, Sodium Sulfite, Sodium Thiosulfate, Sorbital, Starch, Steam, Stearic Acid, Stoddard Solvent, Styrene, Sugar Liquor, Sulfur (molten), Sulfur Chloride, Sulfur Dioxide, Tannic Acid, Tar, Terpene Monocyclic, Thiamin Solution, Titanium Tetrachloride, Toluene, Tomato Juice, Trichlorethylene, Turbine Oil, Turpentine, Urea, Urine, Vegetable Oils, Vinyl Acetate, Vinyl Chloride, Vitamins, Water, Wax, Whey, Whiskey, Wine, Wort, Xylene, Xylenol, Zein, Zinc Sulfate	Phenol
Stainless Steel 316	Acetic Acid (dil.), Acetic Acid Vapor, Acetic Anhydride, Barium Chloride, Chloroacetic Acid Mon., Chlorosulfonic Acid, Ethylene Diamine, Formic Acid, Furfural, Hydrogen Peroxide, Maleic Acid, Maleic Anhydride, Manganese Sulfate, Phosphoric Acid, Phosphorous (liquid), Pulp (paper), Salt Acid, Sodium Bleach, Sodium Nitrate, Sulfite Liquor, Tartaric Acid.	Cresols Cresylic Ac., Ferric Sulfate, Ferrous Chloride, Sulfuric Acid (0-93%)
Steel	—	Acetone, Acetylene, Acrolein, Ammonia, Ammonium Hydroxide, Ammonium Nitrate, Aniline, Argon, Arochlor, Asphalt, Beet Sugar Liquors, Benzol, Black Sul. Liquor, Borax, Boric Acid, Boron Chloride, Butadiene, Butane, Butylene, Calcium Bisulfite, Calcium Hydroxide, Camphene, Carbon Bisulfide, Carbon Dioxide, Carbon Monoxide, Chlorine (pure), Chlorine Dioxide, Chloro Ethane, Chloroform, Clay Slurries, Creosote, Cyanogen Chloride, Cyanohydrin, Cyclohexane, Cyclohexanone, Cyclopropane, Diethylene Glycol, Diphenyl, Dowtherm, Ethane Gas, Ethanolamine, Ether, Ethyl Acetate, Ethyl Acrylate, Ethyl Cellulose, Ethyl Chloride, Ethyl Mercaptan, Ethylene Chlorohydrin, Ethylene Glycol, Ethylene Oxide, Freon, Furfural, Gasoline, Glue, Glycerine, Heptane, Hydrocyanic Acid, Hydrogen Chloride Gas, Hydrogen Sulfide, Hydroquinone, Illuminating Gas, Latex, Lead Nitrate, Lime Slurries, Lithium Chloride, Magnesium Hydroxide, Magnesium Sulfate, Mercaptan, Mercury, Mesityl Oxide, Mixed Acid (sulfuric and nitric), Molasses, Naphtha, Naphthalene, Nitro Benzine, Palmitic Acid, Petrolatum, Phenol, Phenolic Sulfonate, Phenylethylmalonic Ester, Phosgene, Phosphorous (liquid), Phthalic Anhydride, Pine Gum, Potassium Chloride, Potassium Chlorate, Potassium Cyanide, Potassium Hydroxide, Potassium Iodide, Potassium Permanganate, Potassium Phosphate, Potassium Sulfate, Propane, Rosin Emulsions, Silicon Tetrachloride, Soap, Sodium Aluminate, Sodium Carbonate, Sodium Cyanide, Sodium Dichromate, Sodium Ethylate, Sodium Glutamate, Sodium Hydroxide (0-20% and above 50%), Sodium Nitrate, Sodium Oleate, Sodium Phosphate, Sodium Resinate, Sodium Silicate, Sodium Sulfate, Sodium Sulfide, Steam, Stearic Acid, Stoddard Solvent, Styrene, Sulfur Chloride, Sulfuric Acid (93-98%), Sulfuric Acid (fuming Oleum), Tar, Terpene Monocyclic, Thionyl Chloride, Tin Tetrachloride, Titanium Tetrachloride, Toluene, Trichlorethylene, Turpentine, Vegetable Oils, Vinyl Chloride, Wax, Xylene, Xylenol, Zein, Zinc Sulfate
Tantalum	Ammonium Chloride, Aqua Regia, Bromine, Calcium Hypochlorite, Chlorine (water solution), Chloroacetic Acid, Chromic Acid, Ferric Chloride, Ferrous Chloride, Hydrobromic Acid, Maleic Acid, Mercuric Chloride, Mixed Acid, Nitrosyl Chloride, Tin Tetrachloride	—

Adapted from material furnished by Fischer & Porter Co.

HOW FULLER AND REVERE LICKED

a tough brush problem



A—Revere Cupro-Nickel Strip
B—Revere Brass Wire
C—Bristles, loop-anchored in channel
D—Formed and trimmed brush, 3/16" I. D.
E—Complete brush and mandrel

DAIRIES use a great many small cylindrical brushes to clean the insides of pasteurizing and other tubes through which milk flows. The Fuller Brush Company wished to offer this market brushes that would utilize its Fullergript principle, consisting of bristles loop-anchored inside a metal backbone. Such a brush would obviously provide superior cleaning performance, and longer life, than the tufted type. However, the small inside diameters of the dairy tubes meant that the metal backbone would have to be formed into an extremely small and close coil, with the inside diameter of the coil about 3/16". This posed the question: what metal or alloy would withstand this exceptionally severe double deformation?

After a few experiments had proved that the problem was far from easy, Revere was called in. The Revere Technical Advisory Service, after an extended study of the matter, suggested a trial of a certain gauge and type of cupro-nickel strip. A test run proved entirely successful, and regular production soon began. Thus Fuller was enabled to offer its Fullergript brushes to the dairy industry.

This is but one of a great many examples of Revere's successful collaboration with industry. If you have a fabrication problem in non-ferrous metals, get in touch with Revere.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.—Sales Offices in Principal Cities, Distributors Everywhere.

MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Thickness Testers for Plated Metal Coatings

Measuring plated coating thicknesses accurately has always been somewhat of a problem in the plating industry, and from time to time new devices are proposed. Two of the latest are a magnetic method for measuring the thickness of composite coatings of copper and nickel, and a device using the principle of coulometric analysis.

The magnetic method is described by A. Brenner & E. Kellogg in the *Journal of Research*, Apr., 1948. An instrument, known as the Magne-gage, measures the attractive force between the specimen and two permanent magnets of different strengths. It is possible with this device to determine not only the total thickness, but also the relative thickness of the two layers by using a set of calibration curves.

The gage as designed will measure with a satisfactory accuracy composite coatings with total thicknesses from 0.0005 to 0.0030 in. Within this range the error of the gage was found to be about 10% for the total thickness and 15% for the copper percentage determination. For satisfactory performance the sample must have an area at least 1 in. sq., and a radius of curvature of not less than ½ in.

The other recently developed coating thickness tester is described by H. T. Francis in the *Journal of Electrochemical Society*, Mar., 1948. The principle of this instrument is the anodic dissolution of a defined area of the plated metal, using the current-time product as a measure of the thickness. The stripping current is held constant during a test and the removal time is automatically indicated. Successfully measured coatings include: tin, zinc, lead, cadmium, copper, chromium, silver, gold and brass on steel; and tin, zinc, lead, and chromium on brass or copper.

This electrolytic thickness tester is particularly well suited to very thin coatings. Plating thicknesses from a few millionths of an in. up to several ten-thousandths have been measured quite satisfactorily. For coatings heavier than about 0.0005 in., the stripping time becomes rather long—30 min. or more. The accuracy is high; for example, 30 micro-in. of tin on steel can be measured with an accuracy of ± 2%. Composite coatings cannot be measured on this tester.

Long-Time Service Tests of Aluminum Conductor Cables

The competitive position of aluminum as compared to copper for conductor cables has steadily improved as the result of the increasingly favorable price and supply of aluminum. However, there has been little indication as to the behavior of aluminum in long-time service. Therefore, recent studies by the French of cables that had been in service for 5 to 28 yr. are of particular interest. The results of this long-time investigation are reported by J. Herenguel in *Révue de l'Aluminium* (French), Dec. 1947 and Mar. 1948.

Eight Almélec cables in service for 5 to 17 yr. were examined and in some cases compared with duplicate cables that had been in storage for the same period. (Almélec contains nominally 0.7 magnesium, 0.5 silicon, 0.3% iron maximum with the balance aluminum.) Two cables were covered with a black deposit analyzing 50% free carbon, while the others were gray with black spots. No signs of any corrosion were noted. A series of 130 tensile tests showed that, in general, the cables met the tensile and elongation requirements of the specifications. There was no progressive softening nor was there any appreciable difference from the stored cables. It would seem then that the potential life of Almélec cables will be very long since the 17-yr. old cables were absolutely intact.

Also studied were 31 aluminum-steel cables that had been in service for 10 to 28 yr. Almost all were covered with a black, high carbon film, but the aluminum wires were uncorroded despite the fact that one cable has been only 6 miles from the Mediterranean. All the steel centers (galvanized wire) were in good condition except for two, where the corrosion was attributed to improper galvanizing which left a chloride residue on the wire. The mechanical properties of the aluminum and steel wires (even of the corroded steel wires) were normal and comparable to specification values. On the basis of these results, the expectation of a normal life of 50 yr. for aluminum-steel cables does not appear excessively optimistic.

New Magnetic Alloy for Rectifiers

Another magnetic alloy has been added to the rapidly growing list of new magnetic materials. This one, known as Permenorm 5000-Z, was recently reported on by the Naval Ordnance Laboratory. It is a nickel-iron alloy first produced in Germany in 1943 where it was used in huge rectifiers for the electrochemical industry.

Unfinished samples of the alloy were brought to this country from Germany after the war to be duplicated. Difficulty was at first encountered in attempting to reproduce the alloy with the required magnetic properties, because of the complex heat treating process involved. However, the Naval Ordnance Laboratory has now developed a satisfactory process for producing the material in quantities.

The chief use of the new alloy will probably be in rectifiers. It will also probably have applications in magnetic amplifiers to replace the more complicated and delicate electronic tube amplifiers employed in guided missiles, fire control of equipment, and underwater ordnance.

Uniformly Better Results in Heat Treating...

● Using the NIAGARA AERO HEAT EXCHANGER to cool quenching bath solutions returns the cost of the equipment quickly and gives a bonus in fewer troubles for the heat treating superintendent.

Controlling the temperature of the quench means a uniform product...fewer rejections. Ample cooling capacity independent of water supply eliminates shut-downs because of hot oil. The heat is transferred from the oil to air by the evaporation of a water spray. Only the water evaporated is used and 95% of the water cost is saved.

In hundreds of installations, quenching both small parts and large shapes, production has increased at lowet cost. Units operate reliably for years without maintenance troubles in plants that run 24 hours per day.

Niagara Aero Heat Exchangers also give extra value in cooling jacket water for process equipment or engines, hydraulic equipment, electronic sets, controlled atmosphere processes, and many other applications.

Write for Bulletin No. 96-MM

NIAGARA BLOWER COMPANY

Over 30 Years Service in Industrial Air Engineering

405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities

INDUSTRIAL COOLING HEATING • DRYING

NIAGARA

HUMIDIFYING • AIR ENGINEERING EQUIPMENT

DIGEST

Electrically Conducting Glasses

Numerous methods have been developed for increasing the conductivities of glassy materials by the application of metals to the surface or in the bodies of glasses. However, with metal coatings, control of the conductivity of the applied layer is not feasible, because the insulating nature of the oxide surface will predominate up to the point where sufficient metal has been applied to give the surface the high conductivity of the metal itself.

In the *Journal of the American Ceramic Society,* April, 1948, R. L. Green & K. B. Blodgett present the results of an investigation to develop glasses and glazes whose conductivities over various ranges can be controlled accurately. In general, the principle employed was to incorporate into the glass structure, by melting, oxides which could be reduced readily to metals on heating in hydrogen. Initial work on glasses high in lead oxide content was extended to include others containing bismuth oxide and antimony oxide.

The glasses containing sufficiently high contents of lead, bismuth, or antimony oxides, or combinations of these, became electrically conducting when reduced in hydrogen by several hours' heating. Electronic conduction was maintained in a reduced surface layer whose thickness was somewhat less than 0.001 in. Results showed that surface conduction increases as the content of reducible oxide is increased.

New Pickling Solution for Aluminum

Numerous pickles have been introduced for aluminum alloys, but no one of them has proved entirely satisfactory for all alloys and requirements. Now another new pickle, called "Framanol," has been developed in France and is stated to be superior to the older pickles, although admittedly is not perfect. It is described by J. Frasch in *Révue de l'Aluminium,* Mar. 1948.

Framanol is a complex solution of chromium phosphates and triethanolamine. The alcohol and triethanolamine emulsify the grease and oil on the metal, while the superficial aluminum oxide film is dissolved by the phosphoric acid and triethanolamine and, finally, the cleaned metal is lightly passivated by a very thin film of chromium oxide. It is used cold with a pickling time from ½ to 1½ hr., after which the parts are rinsed in water and dried.

Various tests were made on this pickling solution and compared to three of the most

common pickles: 10% caustic soda at 160 F, 15% sulfuric acid + 5% chromic acid at 105 F, and 30% nitric acid. The surface of an aluminum alloy pickled for various times showed much less attack after the Framanol pickle than after the other pickles. The loss in weight during pickling was also least with Framanol, even with pickling times twice or three times the normal value. Framanol pickled samples gave the most noble potential in distilled water.

The contact resistance, of importance in spot welding, showed that there was an optimum time for each of the pickles. Framanol gave the lowest contact resistance; likewise, this low value was obtained with a wider range of times than the nitric acid pickle, which gave the next lowest resistance. As a result of the passivating action of the Framanol, the increase in contact resistance with elapsed time after pickling was less than with the sulfuric-chromic acid or with the nitric acid. These latter tests were confirmed by additional work based on the number of correct spot welds that could be made before the electrodes had to be cleaned.

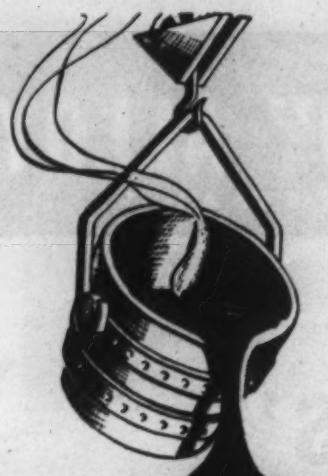
Nickel vs. Chromium Plates

Both nickel and chromium plates are applied to give protection against corrosion. In some cases either is satisfactory, but in other cases one is to be preferred over the other. In *Metal Industry* (English), Mar. 12 and 26, 1948, R. E. Wilson, among other things, gives an excellent comparison of these two electroplates.

Nickel is better for resisting corrosion fatigue and also for resisting fretting corrosion. Of many combinations investigated, the best results with lubricated surfaces were found with a pair of materials of which nickel was one. Hard materials in general appear to produce corrosion debris under such conditions. As a matter of fact, chromium gives a very bad performance.

Chromium shows a great superiority in regard to mechanical wear. Its coefficient of friction is very much lower than that of nickel. Care has to be taken to see that the contacting surfaces are well lubricated. As chromium is not wettable, it has no capacity for absorbing oil. Much research has been done on means of chromium plating cylinders to reduce the wear and at the same time to provide a wettable surface. One example of this is the well known "porous chromium" process.

The easiest method is that used by Rolls-Royce on the Merlin airplane and tank



18-8

it *will* save your money
it *may* save a product
it *has* saved a life

LEBANON CIRCLE Ⓛ 22
An "18-8" Alloy

NOMINAL ANALYSIS

Carbon Max.	0.07
Silicon	1.25
Manganese	0.75
Chromium	19.50
Nickel	9.00

NOMINAL PHYSICAL PROPERTIES

Tensile Strength	75,000
Yield Point	36,000
Elongation in 2"—%	50
Brinell Hardness	135

NO other alloy satisfies the exacting demands of industry in so wide a range of applications as Circle Ⓛ 22, the time-tested "18 and 8". It is saving money every hour of every day by lengthening equipment life, cutting repairs and plant "down-time". It guards product quality against contamination by corrosion. In handling dangerous gases and liquors, men's lives depend on the integrity of castings made from this "18 and 8" alloy.

A set of data sheets describing Circle Ⓛ 22, 22 M and 22 XM, Lebanon's "18 and 8" alloys, is yours for the asking.

LEBANON STEEL FOUNDRY • LEBANON, PA.
"In The Lebanon Valley"

ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON ALLOY AND STEEL Castings
CIRCLE L

"FALLS BRAND" ALLOYS
AMERICA'S LARGEST PRODUCERS OF ALLOYS

"FALLS"
ALUMINUM CASTING ALLOYS
For
QUALITY
DEPENDABILITY
UNIFORMITY
DUPLICATION OF RESULTS
RIGID CONTROL OF COMPOSITION

WRITE FOR COMPLETE DETAILS

NIAGARA FALLS
Smelting & Refining Division
Continental-United Industries Co., Inc.
BUFFALO 17, NEW YORK

DIGEST

engines. The top third of the bore is plated with a thin deposit of ordinary hard chromium, while the rest of the cylinder is untreated. The rate of wear of the unplated portion is reduced because of the absence of the abrasive material which, in untreated liners, is torn from the top of the cylinder and tends to increase the wear towards the bottom of the stroke. The unplated portion takes care of the lubrication of the plated portion. As a result, the life of the liner is increased about ten times.

Stampings from Molten Nonferrous Metals

A unique metal forming method was recently described in *The Engineers' Digest* (British), Feb., 1948, based on an article by N. A. Sokolov originally appearing in the Russian journal, *Vestnik Inzhenerov i Tebnikov*. This process, which involves the stamping of molten metal, differs from ordinary die casting in that the pressure is developed in and by the die itself, and not in an external pressure chamber. Thus, the possibility of porosity is practically eliminated. Briefly, the method consists of placing molten metal in the matrix or female die, after which the plunger or male die descends and forces the metal into the required shape.

The most suitable applications of the process are for bearing bushings and similar components with walls ⅛- to ⅜-in. thick, outside diameters up to 5 in., and length-to-diameter ratios up to 1 to 25. The shape of the internal surface must be such as to permit withdrawing of the plunger. Considerable saving of metal is affected by this method as compared with machining from a forged blank, and from a centrifugal casting. Also, 98% of the molten metal is left in the finished stamping, and the loss by splashing and fin formation is only 2%.

The stamping machine requires two operating cylinders at right angles: one to open and shut the matrix, the other to actuate the plunger. The dies must be made of low alloy heat-treated, heat-resisting steel. One essential of the process is that the metal should not begin to set before pressure is applied. Nor should the metal be overheated, for this can lead to defects because of shrinkage and long cooling time. The best initial temperature of the metal corresponds roughly to that suitable for castings of 1-in. thickness made in metal molds.

DIGEST

New Magnetic Alloy With Improved Permeability

One of the chief concerns of the telephone and communications industry, where usually very small currents are employed, is the development of materials with high initial permeability. And during the past half century materials with higher permeability have been continuously developed. The latest step has been the development of a greatly improved molybdenum Permalloy, called Supermalloy, by the Bell Laboratories. The properties and characteristics of the alloy are reported in the March, 1948 issue of *Bell Laboratories Record*.

Supermalloy has an initial permeability 500 times that of iron. Maximum permeabilities as high as 1,500,000 and initial permeabilities as high as 170,000 have been obtained by properly selected heat treatment. Besides its improved permeability, the hysteresis loss of Supermalloy is also better than that of the molybdenum Permalloy.

By the use of this alloy during the war, transformers for radar apparatus were made to pass a frequency band three times wider than had been possible with the best previous materials. Although still not available commercially, it should find many future applications in the electrical and electronic industries for use in such things as coaxial cable, and radio-relay circuits, as well as for radar and television apparatus.

Effect of the Heating Rate in Surface Hardening

Satisfactory hardening has not always been obtained with flame or induction heating, even when the quench was adequate and the temperature of the surface before quenching was 90 F or more over the usual hardening temperature. The cause is believed by many to be a marked raising of the critical range as the result of the high heating rate and the absence of any soaking at temperature. To check this theory, W. Eilender and R. Mintrop studied the effect of heating on the critical range of a 0.54% carbon steel. Their results were published recently in *Stahl und Eisen* (German), Feb. 26, 1948.

It was found that as the heating rate increased from 225 to 5400 F per sec., the temperature of the maximum rate of formation of austenite was raised about 300 F. Consequently, in flame or induction harden-

G. O. CARLSON INC.

Stainless Steel Forged Rings

G. O. Carlson, Inc. produces stainless steel forged rings in most analyses and in any reasonable sizes. These rings are sold in the "As Forged" condition, "Rough Machined" with allowances for you to finish, or "Finish Machined" to your exact size.

At all times, we have on hand a wide range of sizes and analyses of stainless steel forging stock, which enables us to give you prompt delivery of high quality forged rings. The production of this forging stock and these forged rings, in analyses to meet the highest specification requirements of the chemical industry, falls within the classification of routine production at G. O. Carlson, Inc. Further, we are always prepared to furnish other forged items such as discs, tube sheets, flanges, sleeves, etc. Therefore, if you want a dependable source of supply for stainless steel forgings, get in touch with G. O. Carlson, Inc.

G. O. CARLSON, INC.

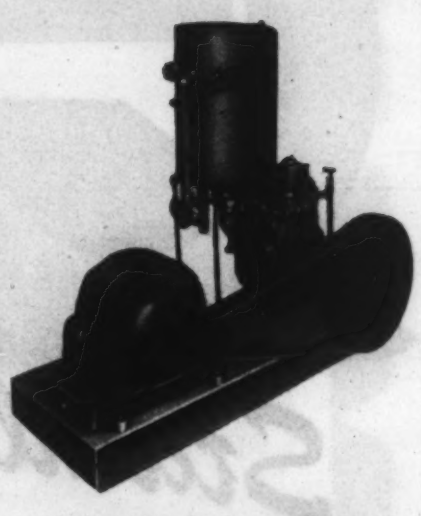
Stainless Steels Exclusively

200 Marshalton Road, Thorndale, Pa.

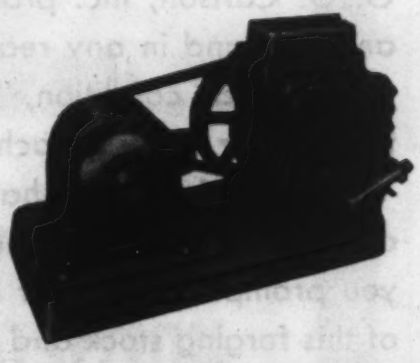
PLATES • FORGINGS • BILLETS • BARS • SHEETS (No. 1 Finish)

Warehouse distributors in principal cities

● Whether you measure your vacuum requirements in *inches* or *fractions of microns*, Kinney Vacuum Pumps will work FAST to produce the degree of nothingness you require. This high pumping speed, plus the ability to produce low absolute pressures day after day, make Kinney Pumps the first choice in Industry for vacuum process applications. Unique rotating plunger design and generous openings, with positive oil seal between rotating parts, contribute to Kinney's exceptionally rapid pump down and long life. Whatever your low pressure requirements, there's a Kinney High Vacuum Pump to give efficient, dependable service — exhausting lamps and tubes, dehydrating foods, producing drugs, sintering alloy metals, coating lenses and performing countless other low pressure operations.



Kinney Single Stage Pumps are available in 8 sizes with displacements from 13 to 702 cu. ft. per min. Will test to low absolute pressures of 10 microns or better.



Kinney Compound Pumps are available in 2 sizes with displacements of 15 and 46 cu. ft. per min. They regularly maintain low absolute pressures to 0.5 micron or better.

Ask for Catalog V45.

KINNEY MANUFACTURING COMPANY

3523 WASHINGTON ST., BOSTON 30, MASS.

New York • Chicago • Philadelphia • Los Angeles • San Francisco

FOREIGN REPRESENTATIVES

GENERAL ENGINEERING CO. (RADCLIFFE) LTD., Station Works, Bury Road, Radcliffe, Lancashire, England

HORROCKS, ROXBURGH PTY., LTD., Melbourne, C. I. Australia

W. S. THOMAS & TAYLOR PTY., LTD., Johannesburg, Union of South Africa

WE ALSO MANUFACTURE LIQUID PUMPS, CLUTCHES AND BITUMINOUS DISTRIBUTORS

DIGEST

ing, the surface of the steel must be heated to a temperature considerably above the usual hardening temperature in order to get satisfactory results.

Also, it was found that the higher the heating rate, the more rapid was the formation of austenite. The carbon distribution in austenite is more or less non-uniform, depending upon the prior structure, heating rate and holding time. Since both flame and induction hardening involve a very fast heating rate and at the most a very short holding time, the only way to obtain a homogeneous austenite (and consequently a homogeneous martensite on quenching) is by proper selection of the prior structure. The most favorable prior structure is martensite, since the carbide particles in it are fine and uniformly distributed. With a pearlitic prior structure, the uniformity of the austenite will be greater, the finer the pearlite lamellae. Spheroidized material gives the least uniform austenite and, therefore, should be avoided in steel which is to be flame or induction hardened.

Recent Developments in the Production of Iron Castings

In the *British Foundry Trade Journal*, Apr. 8 and 15, 1948, a comprehensive review of technical developments in iron castings was presented by E. C. Dickinson. Space allows only several of the developments to be mentioned.

The process which promises to have the most outstanding influence on the future of iron castings is the production of nodular graphite as-cast. With nodular graphite, the strength and shock resistance are much higher than in ordinary cast iron. The absence of the normal graphite flakes, however, will probably affect the fatigue ratio, damping capacity and wear resistance. The nodular iron can be produced in a cupola (by late additions of cerium, generally as Mischmetall) but the process is as yet applicable only to high carbon, low phosphorus, low sulfur material. Desulfurizing with sodium carbonate has proved valuable in obtaining the requisite low sulfur contents.

Di-electric high frequency drying of cores seems to offer many advantages. A 10-lb. core, for example, can be so dried in about 3 min., as compared with 60 to 90 min. in a conventional stove. Most of the experimental work has used a urea formaldehyde bond because it sets immediately at a relatively low temperature. This plastic bond has a low gas content when dried and strips

DIGEST

well, but is likely to break down in frail cores and has a disagreeable odor when roasted cores are torch dried. The normal molasses-linseed oil bond, which relies on loss of moisture and oxidation for strengthening, can also be dried with di-electric heating by suitable adjustment of time and temperature.

The question as to whether this core drying method is economically satisfactory must be answered by each foundry in the light of its own conditions. One asset is the reduction in the floor space for drying. Also, since cores can be dried quickly, the volume of core storage can be reduced significantly.

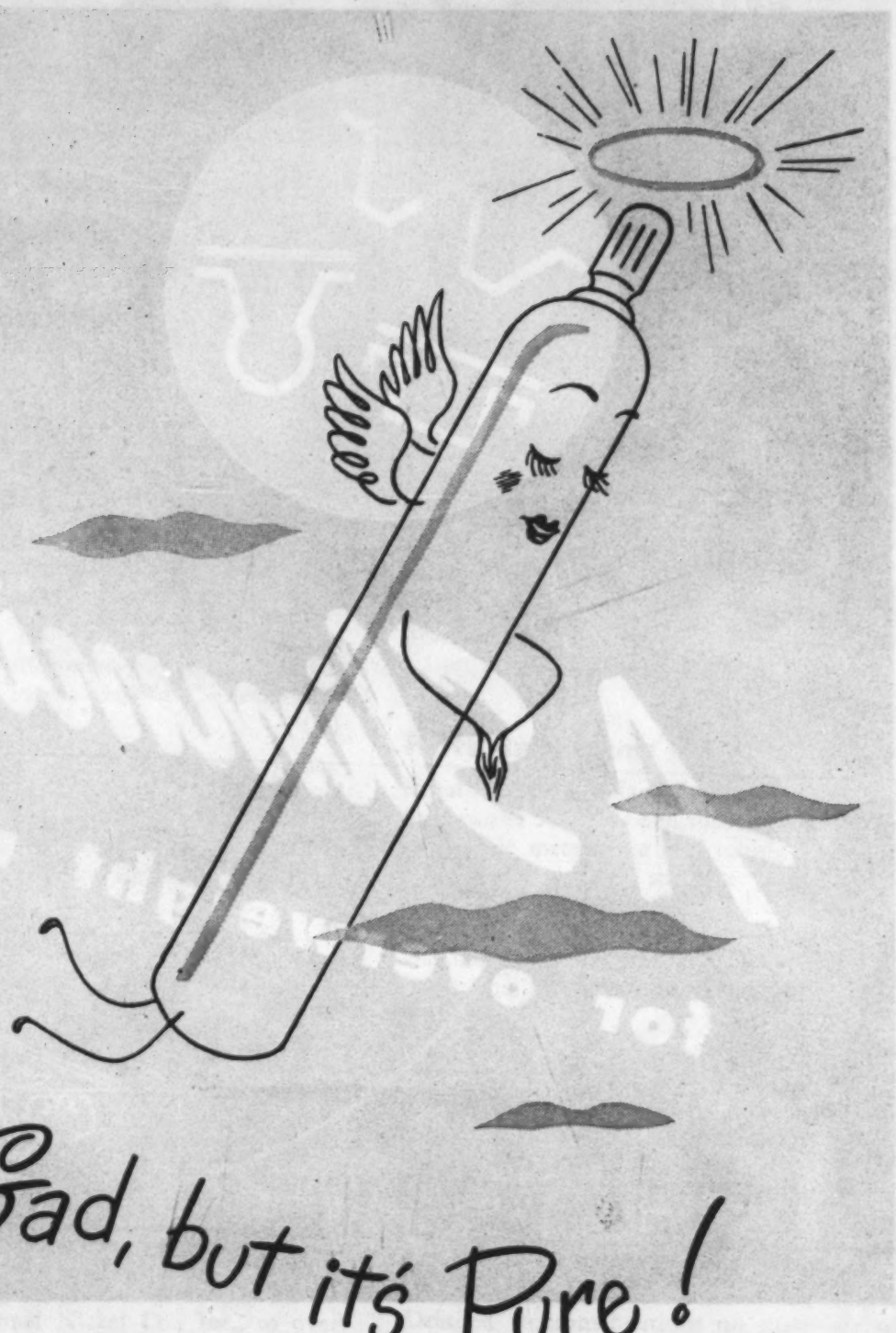
Caustic Cleaning of Large Castings

Huge castings of certain types can be cleaned safely and economically by electrochemical methods, and adoption of the method, in part, may follow current demands for high-quality steel castings that are entirely free from embedded and fused sand.

These conclusions were reached in a paper presented by J. A. Wettergreen ("Electro-Chemical Cleaning of a Large Steel Casting—An Experiment") at the recent meeting of the American Foundryman's Assn. in Philadelphia. He described the successful cleaning of an 18,300-lb. casting by this method at General Electric's Schenectady Works.

The casting involved was the lower shell of a turbine, with a pouring weight of 43,300 lb. Its analysis was 0.20 carbon, 0.76 manganese, 0.37 silicon and 1.10% molybdenum. Appproximately 19,000 lb. of flake caustic soda were charged into the preheated tank, and 11,000 lb. were added at intervals during the first 24 hr. The melting temperature was approximately 575 F, and no particular difficulty was encountered in the melting.

After preheating the casting in an electric car bottom furnace to 750 F to eliminate all moisture and prevent chilling the molten caustic bath, the casting was lowered into the bath by an overhead travelling crane. For the oxidizing cycle 2200 amp. for 3 min. was applied, and for the reducing cycle, the polarity was reversed and cleaning was continued at 4000 amp. at 6 or 7 v. for about 2 hr. After observation of the results, the casting was cleaned again for 2½ hr. It was then allowed to drain and washed down with a fire hose. From this experiment the author concluded that solution of sand deposits is a certain method of assuring freedom from embedded and fused sand.



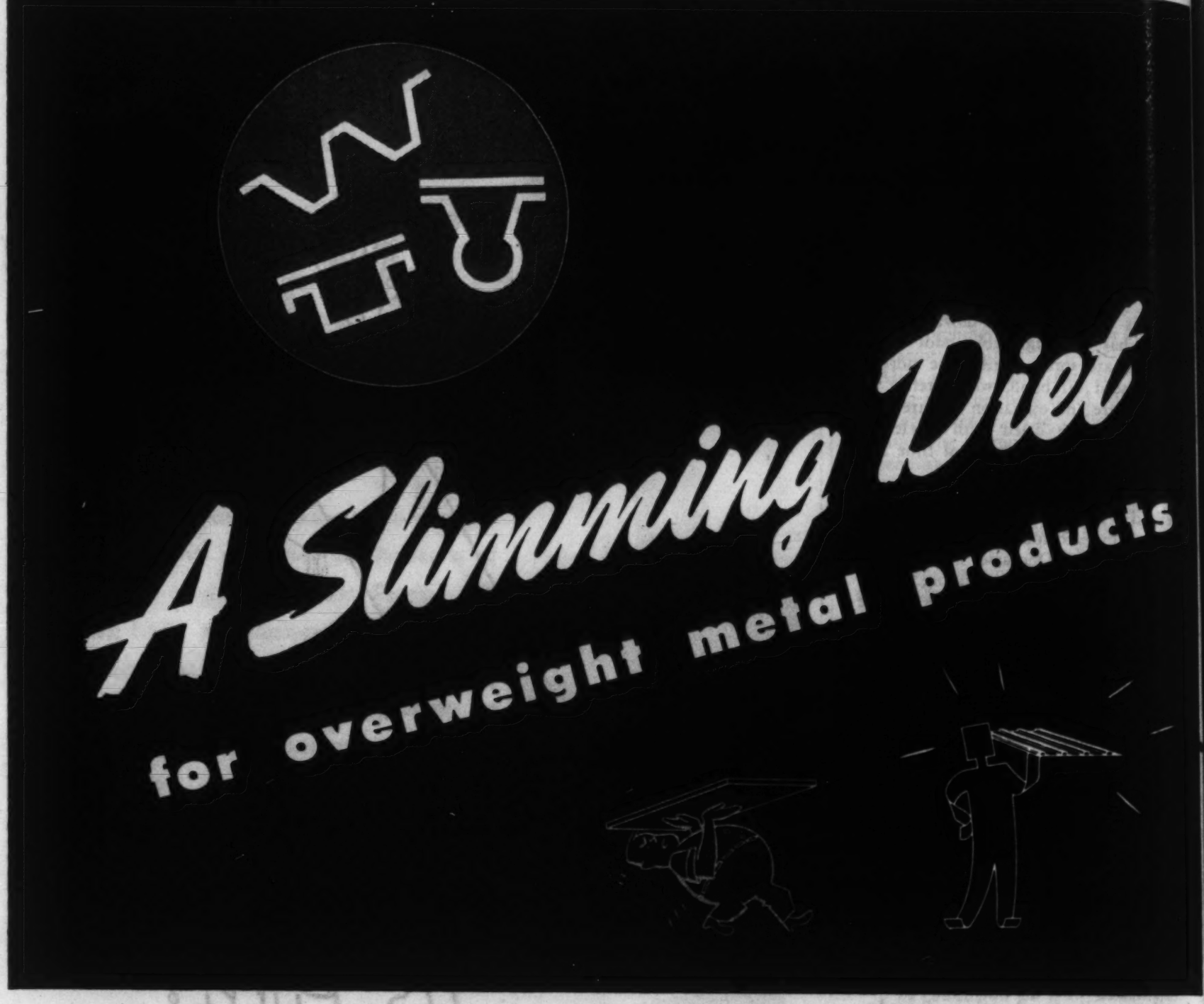
Gad, but it's Pure!

Purity is bred into Mathieson Ammonia. We purge every trace of foreign element from its forebears—nitrogen and hydrogen—then combine these gases into the purest ammonia obtainable.

And do you think we stop there? Not by your pyrometer! Cylinders are thoroughly checked before each shipment. Valves get a special going over. And as for moisture, non-condensable gases and other impurities—they're ushered coldly out. Prompt deliveries of that good Mathieson Ammonia in 100- and 150-lb. cylinders from any of 44 warehouses. Write for free 40-page booklet: "Ammonia in Metal Treating." Mathieson Chemical Corporation, 60 East 42nd Street, New York 17, N. Y.

Mathieson
AMMONIA

Ammonia, Anhydrous & Aqua...Caustic Soda...Soda Ash Bicarbonate of Soda...Liquid Chlorine...Dry Ice...Chlorine Dioxide...HTH Products...Fused Alkali Products...Sodium Chlorite Products...Carbonic Gas...Sodium Methylate



Would your products look better, operate more efficiently, if they could be made *lighter* without sacrificing strength?

Chances are the answer is "yes." And chances are *good* that you can do this job with ARMCO High Strength Stainless Steels. The problem of using them effectively—without increasing ultimate costs—is usually one of *proper design.*

USE OF STIFFENERS

Sufficient rigidity can often be obtained with light sheets of ARMCO Stainless Steels by increasing section-depth, such as by corrugating. Where localized deflection is apt to occur, stiffeners like those shown here are often used to strengthen parts subjected to heavy stresses.

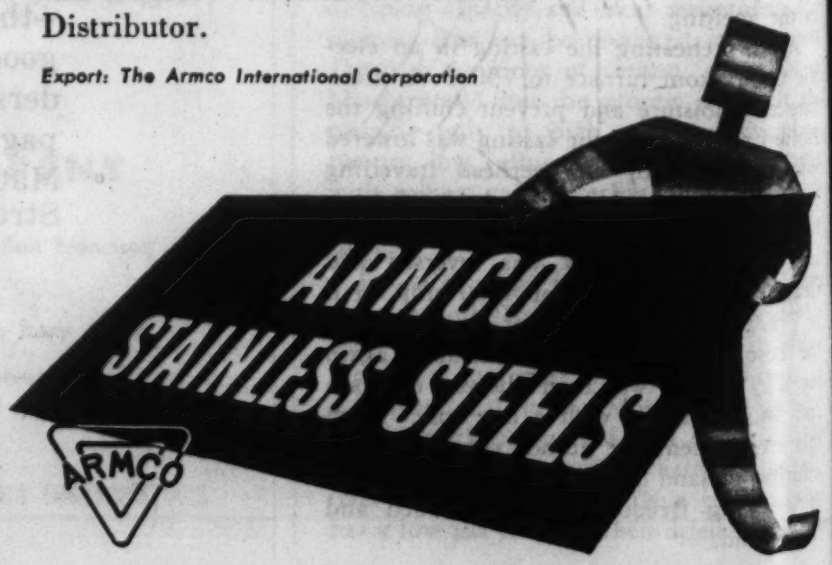
These sectional shapes, welded or riveted to the structure, prevent buckling and supplement the inherent high yield strength obtainable in specially processed stainless grades. They may take such forms as angles, channels, and hat-sections.

OTHER SALES ADVANTAGES

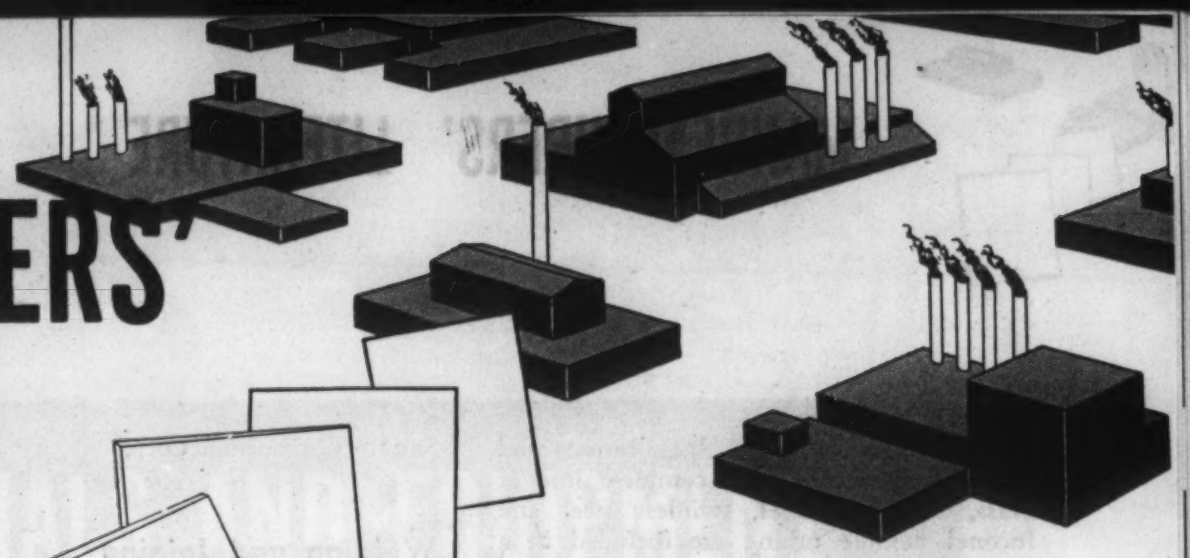
Strength by design has given more than one product a strong foothold in a highly competitive market. Combine this with all the other advantages of ARMCO Stainless Steels—resistance to heat and corrosion, an enduringly beautiful finish, lasting customer appeal—and you have a powerful sales weapon.

These excellent properties of ARMCO Stainless Steels may be the means of improving *your* products, or those you are designing for the future. Let Armco's engineers work with you; and then you be the judge. Write Armco Steel Corporation, 404 Curtis Street, Middletown, Ohio. Or call our nearest district office or Armco Distributor.

Export: The Armco International Corporation



MANUFACTURERS' LITERATURE



Materials

Iron and Steel

Stainless Plates. The selection and fabrication of both solid stainless steel and stainless clad plates, whether used alone or in combination with each other, is discussed by the Allegheny-Ludlum Steel Corp. in an attractive, 32-page, illustrated bulletin. Tables and charts showing available sizes, thicknesses, weights, etc. are included. (1)

Stress Calculation. Typical applications of formulas and charts for use in connection with a preceding bulletin, No. 26, on computing maximum stresses and deflections in circular flat pieces cast in Meehanite metal, are compiled in this 8-page, illustrated supplement issued by Meehanite Metal Corp. (2)

Heat Treated Bar Steel. The mechanical properties, hardness readings, machinability ratings and typical applications of RY-AX steel, a heat treated carbon-manganese hot rolled bar steel produced by Joseph T. Ryerson & Son, Inc., are all included in this 4-page, illustrated bulletin. (3)

Nonferrous Metals

Pipe and Tube Bending. Practical methods for bending pipe and tubes of copper, brass and related alloys are interestingly presented in this 48-page, illustrated handbook, third edition, just revised by the Copper & Brass Research Assn. (4)

Copper-Base Casting Alloys. Quality and specification control, metallurgical considerations, and properties of a variety of copper-base casting alloys are all contained in this 52-page, illustrated catalog, No. 102, published by Federated Metals Div., American Smelting & Refining Co. Complete and detailed specifications are included. (5)

Cerium Metal. The many advantages of using Cerium Metal (Mischmetal) as an alloying element for improving the physical properties of many metals are reviewed in this 4-page, illustrated bulletin, No. 101, just released by the General Cerium Co. (6)

Refractory Metal Powder. Typical applications, physical properties and chemical and screen analyses of Stainless Steel Powder Type 18:8, a refractory metal powder with good green strength, are listed in this 2-page bulletin released by Charles Hardy, Inc. (7)

High Temperature Alloys. All available data on the complete line of alloys for high temperature service produced by the Haynes Stellite Co. are compiled in this attractive, 88-page, illustrated catalog, No. F-6612, including tables and graphs of chemical composition, and physical, mechanical, tensile and stress-rupture properties. (8)

High Nickel Alloys. This new, 36-page, illustrated booklet lists almost 100 service stories showing how electrical manufacturers have used Inco high nickel alloys, produced by International Nickel Co., Inc., to overcome corrosion, heat, vibration fatigue, wear and other performance hazards. (9)

Aluminum and Bronze Powder and Paste. The Magna Manufacturing Co., Inc. presents a complete line of Magnaflake aluminum and gold bronze powders and pastes in their 4-page, illustrated bulletin. (10)

Forgeable Bearing Alloys. The physical and mechanical properties of two forgeable alloys that have been added to the 600 Series of forgeable bearing alloys, produced by the Mueller Brass Co., recommended machining instructions and typical applications are all included in this 24-page, illustrated catalog. (11)

Fabricating Semi-Precious Metals. Various types of plant equipment of special design fabricated in stainless steel, nickel, Monel and Inconel by Storts Welding Co., Inc. for corrosion resisting and heat resisting applications are described and illustrated in this 4-page bulletin. (12)

Rectangular and Square Bars. The Titan Metal Mfg. Co. has issued a 6-page, illustrated bulletin covering rectangular and square bars made from eight different Titan alloys, and includes analyses of the alloys, dimensional tolerances of various sizes of bars, and the weight per ft. of different sizes. (13)

Vanadium Alloys, Metals and Chemicals. Detailed descriptions of a complete line of Vancoram (ferro-vanadium) alloys, metals and chemicals, produced by the Vanadium Corp. of America, are featured in this attractive, 38-page, illustrated catalog. (14)

Parts and Forms

Metal Hose and Tubing. Bulletin No. G-180, four pages, describes and illustrates a variety of flexible metal hose and tubing available in galvanized and stainless steel, brass, bronze, Monel, aluminum, and other workable alloys in sizes from ⅛ to 20 in. I.D., and includes typical applications. American Brass Co., American Metal Hose Branch. (15)

Specialized Metal Production. The facilities of the various divisions of Continental-United Industries Co., Inc., which make tool steel; weave metal cloth for wire screening; design and produce tools, dies, fixtures and stampings; fabricate pipelines, storage vessels and penstocks; etc. are illustrated and described in this 20-page catalog. (16)

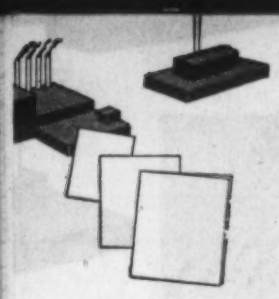
Construction Materials for Corrosive Fluids. Detailed recommendations on materials of construction to be used in Flowrator instruments for measuring almost 400 different corrosive liquids and gases are given by the Fischer & Porter Co. in their 4-page bulletin, No. 97. (17)

Steel Tubing. Typical applications, specifications, and tables of Electricweld round tubing—weight per lineal ft., round tube tolerances, gage tolerances, etc.—are featured in this 20-page, illustrated catalog published by the Jones & Laughlin Steel Corp. (18)

Precision Investment Casting. Typical applications of the Microcast Process, a precision investment casting technique originated by the Microcast Div. of Austenal Laboratories, Inc., are featured in this 2-page, illustrated bulletin. (19)

Design-Strengthened Metal. Rigid-Tex Corp. offers an 8-page, illustrated reprint containing detailed information on Rigidized Metal, a design-strengthened engineering material available in 18 patterns that increases strength and rigidity, and has the added advantage of attractiveness. (20)

Metal Tubing. The Superior Tube Co. lists a variety of fine small tubing ranging from 0.010- to 0.625-in. O.D. maximum in many metals, and includes a commercial tolerance table in their 4-page, illustrated bulletin. (21)



MANUFACTURERS' LITERATURE

All-Metal Flexible Hose. Specifications and typical applications of a complete line of brass, bronze, Monel, stainless steel and Inconel flexible tubing are included in a 24-page, illustrated catalog, No. 113, issued by Titeflex, Inc. (22)

Plastics

Plastic Molding. The facilities of the Tech-Art Plastics Co. for handling the most complex plastic molding problems are featured in this 6-page, illustrated folder. (23)

Chemical Products. Approximately 100 chemicals produced by the Hercules Powder Co. are divided into family groups—cellulose, synthetic resins, rosin, terpene solvents and chemicals, chlorinated products, dairy products, and explosives and sporting powders—in this attractive, 20-page, illustrated bulletin, No. 689 (24)

Nonmetallics

Comparing Rubbers. An interesting 8-page, illustrated reprint on the comparing of rubbers with respect to their properties, mechanical applications and economies in production has been issued by the Ohio Rubber Co. (25)

Methods and Equipment

Heat Treating

Induction Heaters. This new 12-page bulletin, No. 15B6430A, describes and illustrates numerous examples of successful brazing, soldering, hardening, annealing and heating with a variety of induction heaters ranging in size from 1 to 100 kw., produced by the Allis-Chalmers Mfg. Co. Specifications are included. (26)

Electric Furnaces. Specifications, dimensions and applications of a variety of special high temperature electric furnaces using Globar nonmetallic heating elements are included in this 36-page, illustrated folder, issued by Harper Electric Furnace Corp. (27)

Clean Hardening Furnaces. Both continuous and batch type clean hardening furnaces for producing a suitable protective atmosphere for surface-protected hardening are described and illustrated in this 4-page bulletin, No. SC-138, just released by the Surface Combustion Corp. (28)

Welding and Joining

Arc Welding Electrodes. A new 32-page, illustrated pocket guide to the correct selection of Airco arc welding electrodes for a specific job is offered by Air Reduction Sales Co. Also included is an easy-to-read electrode selection table, a NEMA standard color marking chart, and an electrode comparison chart. (29)

Stainless Steel Fastenings. A complete stock list of anti-corrosive fastenings made of stainless steel now available from Anti-Corrosive Metal Products Co., Inc. is presented in this 4-page, illustrated bulletin, No. PL-4-48. (30)

Arc Welder. Complete specifications and data on the Nu-Arc general purpose a.c. arc welder, which has no moving parts to repair or replace and is portable, are presented by Electric Arc, Inc. in a 2-page, illustrated bulletin, No. N-1. (31)

Resistance Welders. The many advantages of using Tri-Phase (three-phase balanced power load) resistance welders for spot, projection, seam and upset butt welding operations are listed by Taylor-Winfield Corp. in their 8-page, illustrated bulletin, No. 10-813. (32)

Stored Energy Spot Welder. The advantages of decreased power consumption, improved quality of welds and higher production through the use of the stored energy spot welder produced by Vangtronic Corp. are discussed in this 8-page, illustrated folder. (33)

Forging and Forming

Sheet Metal Tools. Five basic tools, with accessories, for fabricating sheet steel up to 20-gage and softer metals in correspondingly heavier gages are described and illustrated in this 16-page bulletin issued by Berkroy Products, Inc. (34)

Pipe and Tube Bending. Practical methods for bending pipe and tubes of copper, brass and related alloys are interestingly presented in this 48-page, illustrated handbook, third edition, just revised by the Copper & Brass Research Assn. (35)

Punch Presses. Complete specifications and technical engineering data on a variety of open-back inclinable punch presses, produced by the Diamond Machine Tool Co., are presented in this new 12-page, illustrated bulletin. (36)

Hydraulic Presses. A complete line of straight side, post type and special types of hydraulic presses, with capacities ranging from 75 to 5000 tons and featuring the Hydrol Speed Circuit, a new simplified hydraulic system that minimizes high pressure piping and valving, is described and illustrated in a 12-page bulletin, No. H-47, issued by the Verson Allsteel Press Co. Detailed specifications are included. (37)

Sheet-Metal Fabricator. This 12-page, illustrated bulletin, No. 10-A, features the Wales Fabricator with Hydra-New-Matic drive which punches, notches, nibbles, bends, blanks and form sheet metal products with a versatility heretofore unequalled. Specifications are also included in this bulletin, just released by Wales-Strippit Corp. (38)

Machining

Wet Abrasive Cutting Machine. The new Model 223 Bar Cutter, a low cost wet abrasive cutting machine designed to cut 2-in. dia. solid stock and 3½-in. tubing and will cut practically any material, is featured in a 4-page, illustrated bulletin, No. GH-30, just released by the Andrew C. Campbell Div. of American Chain & Cable Co., Inc. Specifications are included. (39)

Grinders, Polishers, Etc. A complete line of abrasive and flexible belt grinder-polishers, abrasive belt grinders, polishing and buffing lathes, bench backstands, etc. is described and illustrated in an 18-page bulletin, No. 325, issued by Hammond Machinery Builders, Inc. Detailed specifications are included. (40)

Contour Boring and Turning Machines. The many advantages of using the new precision contour boring and turning machines that are cam and air actuated are discussed by the New Britain-Gridley Machine Div., New Britain Machine Co., in their 6-page, illustrated folder, No. 682. Specifications are included. (41)

Jig and Fixture Parts, Stud Sets, Etc. The reduction of set-up time on jig borers, milling machines, slotters, planers, boring mills, punch presses, etc. through the use of jig and fixture parts, T-nut and stud sets, and step block sets is discussed by the Northwestern Tool & Engineering Co. in a 4-page, illustrated bulletin. Specifications and prices are included. (42)

Electric and Air-Driven Sanders. The many advantages of sanding wood, metal and composition with either the Sterling 1000 portable electric sander or the Sterling Speed-bloc portable air-driven sander are featured in an 8-page, illustrated bulletin, No. 110161, offered by the Sterling Tool Products Co. Prices are included. (43)

Carbide Tipped Cutting Tools. This 60-page, illustrated buyers' guide catalog, No. 646 Revised, contains detailed descriptions, specifications and prices of a complete line of standard carbide tipped cutting tools produced by the Wendt-Sonis Co. (44)

Cleaning and Finishing

Aluminum Paints. The many advantages of using Tuf-On aluminum paints for stopping corrosion and brightening surfaces, plus a selector chart containing properties, applications and resistance data on nine aluminum paints, are featured in this 6-page, illustrated

New MATERIALS AND EQUIPMENT

Spot Welding Guns Designed with Interchangeable Parts

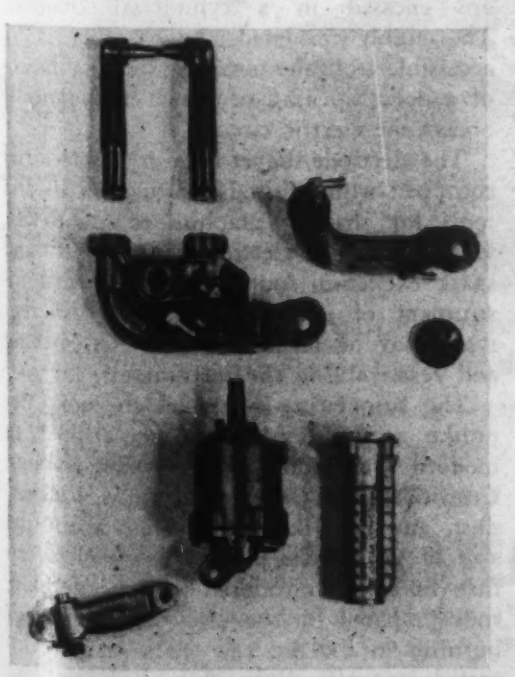
A line of standardized spot welding guns, designed with and constructed from interchangeable standardized component parts has been announced by *Progressive Welder Co.*, 3050 E. Outer Drive, Detroit 12. With this development, it is claimed that seven basic gun types, in heavy duty and standard duty versions, will take care of 95% of all gun welding requirements. A gun can be converted to a different job by changing one or two standardized low cost parts.

Basic standardized components of the welding guns are the gun chassis, the "jaw extensions," the interchangeable hydraulic or air operating cylinders, optional cable locations, handles, and "universal" cable terminal clamps, switches, electrodes, and electrode holders.

In addition to standardizing gun components, most of which are interchangeable between all guns of the new standard line, many of the other units—such as boosters, air valves, and other sub-assemblies—comprising a complete gun installation have also been standardized.

The guns are designed to take interchangeable hydraulic or air operating cylinders to suit individual plant requirements. Use of standardized cylinders and gun components permits pre-determination of the exact pressures to be expected for each installation, even when the same gun is changed to suit a different set of conditions (as through changing jaw extensions to longer or shorter throat depths). Cylinders of different capacities may be interchanged on the same chassis mounting.

Design of gun jaws enables guns to be provided with interchangeable jaw extensions to suit almost any requirement. The standard jaw extensions are available in 1-in. increments of length from 1 to 6 in. and with four (0 deg., 10 deg., 20 deg., and 30 deg.) variations for the angle at which the electrodes are mounted.



A welding gun disassembled to show standardized parts that may be interchanged to vary gun design.

New Solvent Cleaner Features Rapid Cleaning Action

A new emulsifiable solvent cleaner that dilutes with water for cleaning of metal parts in pressure spray-type washing machines has been announced by *Oakite Products, Inc.*, 22 Thames St., New York 6. The Compound, No. 97, forms water emulsions suitable for spray application in single or multi-stage metal washing machines for cleaning steel, brass, aluminum, zinc and other metals before electrocleaning or prepaint treatment or between processing operations.

This cleaner is particularly suited for sheet metal and die castings to remove buffing compounds, drawing and stamping compounds, cutting and grinding compounds, mill and slushing oils, other rust-preventives, cutting and machining oils, metal chips, and shop dirt.

Among the reported features of the cleaner are its rapid cleaning action, nonfoaming properties, and the imparting of a temporary rust-retarding film to the work.

Tinning Pencil Is Handy for Repair Work

Rustproofing metal, regalvanizing spots, tinning bearings can be done with the new touch-up pencil, called Kromover, manufactured by *All-State Welding Alloys Co., Inc.*, 96 West Post Road, White Plains, N. Y. It will tin oil-impregnated bronzes, burned cast iron, all stainless steels, and black iron without removing mill scale.

The preparation consists of wiping off the oil and dirt with a clean rag; the surface tinned will be good for soldering but a little darker than if the metal had been ground down beforehand. The protective coating formed by the pencil is corrosion resistant and, unlike tin-plating, it sacrifices itself to protect the iron and steel on which it is applied.

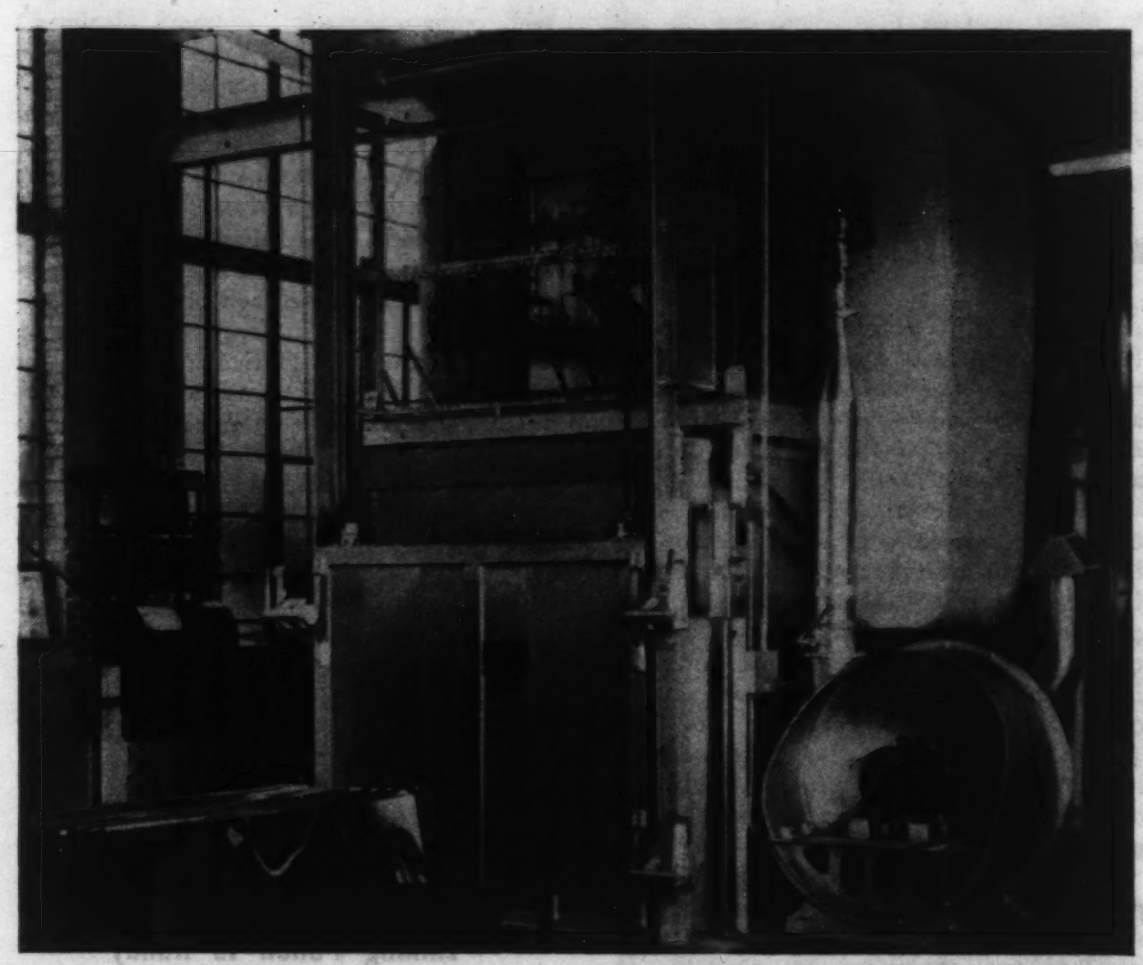
Dismantling is usually unnecessary for applying the pencil. It goes on at 450 F and can be applied with oxy-acetylene, air-acetylene, or city gas flame.

Oven for Annealing Aluminum Coil and Sheet

An oven for annealing coil and sheet aluminum, with a production capacity rated at 3000 lb. of metal per hr. at an operating temperature of 850 F, has been announced by the *Gehnrich Oven Div.* of *W. S. Rockwell Co.*, Fairfield, Conn. The oven, having a work chamber 5½ ft. wide by 19¼ ft. long by 6 ft. high, is of insulated dual panel assembly, with interior chamber sheathing of stainless steel and exterior of black steel painted with heat resistant paint. Counterweighted, chain-operated lift doors are located at both ends of the oven for charging and discharging. The oven floor is provided with tracks to accommodate four-wheel work trucks.

The heating and recirculating system is located directly over the oven. The oven is heated by an external air heater fired by a combination oil-gas burner, having air-oil and air-gas ratiotrols to proportion the required amount of fuel with the air supplied by a turbo-blower. This permits conversion to either fuel or use of both gas and oil simultaneously. The heated air is drawn from the air heater by the recirculating fan into the work chamber. Return ducts located along the top of the work chamber, at each side wall, return the air to the combustion chamber for reheating and recirculation.

Full safety protection against flame failure is provided by safety shut-off valves for either fuel in event of failure of air supply to the burner, or fuel line failure. A high temperature limit switch protects the fan and fan motor in event of excessive temperature in the output side of the recirculating fan. The oven temperature is held within extremely close limits by a thermocouple-controlled indicating-recording instrument.



This aluminum annealing oven is heated by an external air heater fired by a combination oil-gas burner.

Temperature Accurately Maintained with New Electric Heaters

A new series of heavy-duty electric heaters designed for super-heating steam and pre-heating air and other gases used for processing, drying, vacuum packing, conditioning plastics powders, and other applications requiring dry heat, has been announced by *Edwin L. Wiegand Co.*, 7523 Thomas Blvd., Pittsburgh 8.

Temperatures up to 750 F are rapidly reached and accurately maintained by thermostatic controls. Three sizes are available: Series 2 with 2-in. standard pipe; Series 3 with 3-in. standard pipe; Series 6 with 5-in. standard pipe. Capacities range from one to 12 kw. Two or more heaters may be connected in series for larger capacities.

Steam, air or gas enters through lower pipe connection, passes upward through larger steel pipe chamber, and flows out through upper pipe connection. Heating unit is electric tubular type, available in either steel or alloy sheath, depending upon temperature application. Heating chamber is constructed of seamless steel pipe and is insulated against heat losses. Vapor-proof and explosion-resistant terminal covers are available for applications requiring protected terminals. Standard heater flange is 150 lb. forged steel, 300 lb. forged steel flange being used for higher pressures.

A number of different automatic controls are available. Standard range is 200 to 550 F and 100 to 1000 F; others available on request.

Accessories Developed for Spectrographic Equipment

Development of five new accessories for use in spectrographic analysis has been announced by *Bausch & Lomb Optical Co.*, 635 St. Paul St., Rochester 2, N. Y. The accessories include a densitometer, a spectrum plate projector, a safety arc and spark stand, an electrode shaper and a briquetting press, all of which may be used with any spectrograph, regardless of the make or design.

The densitometer permits direct reading and/or continuous recording of the density of the lines in an analytical spectrum, for determining quantitatively any element present in the specimen. The spectrum plate projector aids identification of unknown elements in any specific material or specimen. A special mirror arrangement throws the spectral image on a screen built into the projector, or onto a wall screen when greater magnification is desired for observation by a group.

To insure complete protection in using the dangerously high voltages (2 to 10 amp. at 110 to 15,000 v.) needed to burn the specimen in the arc for spectrographic analysis, the safety arc and spark stand was developed. The "live" parts of the circuit are encased in a cylindrical chamber. Thoroughly insulated, the chamber is inaccessible from the outside, except by means of a door, opening of which automatically breaks the electric circuit.

The electrode shaper has a rotatable turret equipped with adjustable cutters, drills and tools for shaping graphite rods into the various standard electrodes used as arc and spark excitation sources. It is the first instrument of its kind on which different types may be made without disassembling and reassembling the instrument.

The briquetting press, which looks not unlike an old-fashioned coffee-grinder in modern dress, compresses powdered drugs, chemicals, plant ashes, drill chips, hacksaw dust, and the like, into pellets about the size of an aspirin tablet. The pellets can then be easily introduced into the graphite rods prepared on the electrode shaper for burning in the arc and spark stand. Operated manually, little effort is required to produce pressures up to 16,000 lb. to compress the material into pellets.

SEE HOW "THE NEW ARITHMETIC IN STEEL"* MAKES EVERY FOURTH PART A BONUS PART

* 3 TONS > 4 TONS
N-A-X HIGH-TENSILE CARBON SHEET STEEL

N-A-X HIGH-TENSILE stretches production per ton. Its greater strength and corrosion resistance make it possible to design sections an average of 25% lighter. That means one extra product for every three you are now building.

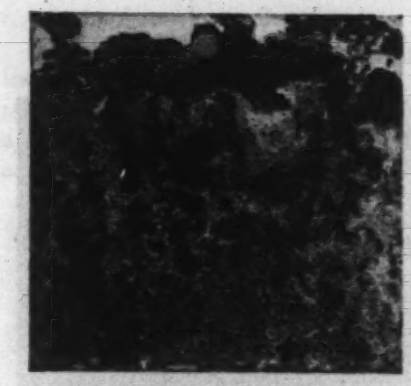
GREAT LAKES STEEL CORPORATION
N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
UNIT OF NATIONAL STEEL CORPORATION

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N·A·X
HIGH-TENSILE STEEL

COPYRIGHT 1948 GREAT LAKES STEEL CORP.

Alodize Aluminum

FOR THE UTMOST IN METAL AND FINISH PROTECTION



ALKALI CLEANED
500 HOURS S. S.

Comparative salt spray test on 24St aluminum. Both panels were finished with one coat of baked refrigerator white enamel. Notice that after only 500 hours the paint system on the alkali-cleaned panel is almost entirely destroyed and the aluminum itself is badly corroded. In contrast, the paint finish is still intact on the Alodized panel after 2000 hours' exposure.

ALODIZED
2000 HOURS S. S.

The Coating

"Alodine" produces a thin, tough, tight, skin-like coating firmly embedded in the aluminum. This protective skin is extremely resistant to corrosion and bonds paint firmly to the metal for the life of the finish.

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING

Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING

Deoxidine *
Peroline *

PICKLING ACID INHIBITORS

Rodine * ®

The Process

Alodizing is simple, quick, economical, easy to operate and effective. "Alodine" can be applied by immersion, spraying, or brushing. It can be utilized to advantage in your own production. Write or call for the new descriptive folder on "Alodine".

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of Metallurgical, Agricultural and Pharmaceutical Chemicals

Phenolic Plastic Developed for High Temperature Applications

Availability of a new thermosetting cast phenolic in sheets, rods, tubes and shapes cast to specifications has been announced by *Catalin Corp. of America,* 1 Park Ave., New York 16. It is useful where service conditions require heat distortion up to 325 F coupled with high compressive and good impact strengths.

In appearance, this material retains the finish inherent in cast phenolics. Colors now available are red, green, blue and black. It has a hard surface (100 to 120 on the Rockwell H scale), and resists scratching

A few typical shapes that can be made with the new phenolic plastic.

and abrasion. Other advantages claimed for the plastic are practically zero water absorption, excellent dimensional stability, and improved chemical and electrical properties.

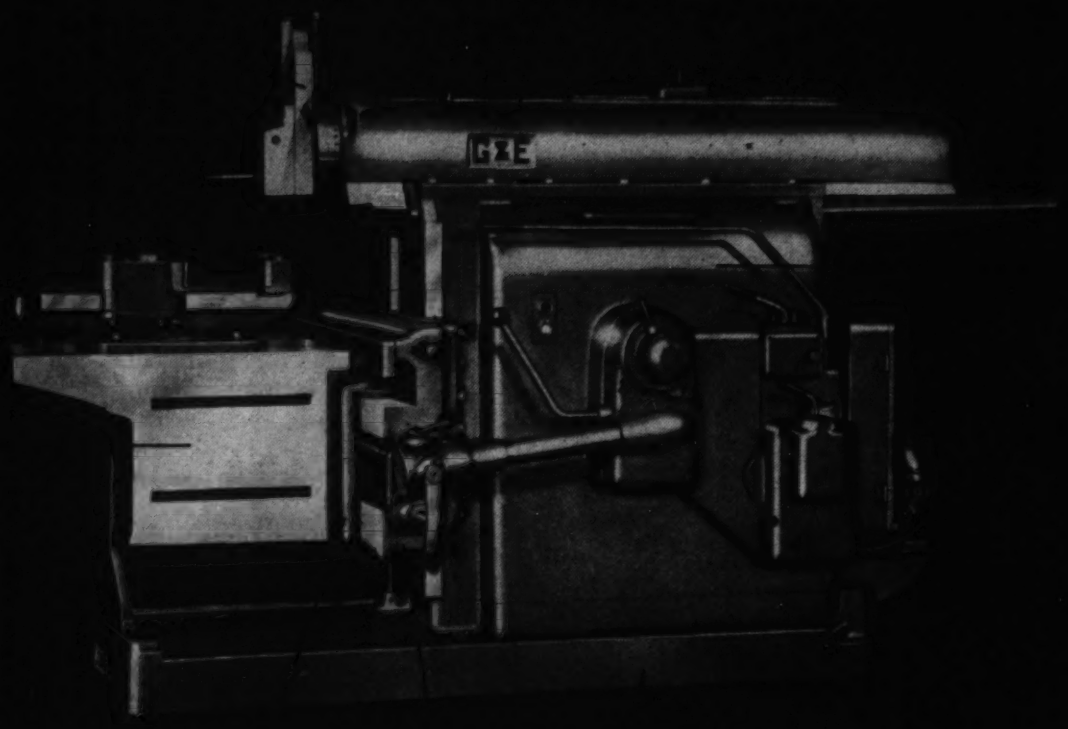
Recommended uses include handles and knobs on aluminum ware, cooking utensils and industrial applications, where its thermosetting properties, appearance, non-inflammability and heat resistance are desirable.

New Torch Provides a Versatile Cutting Tool

Of interest to users of hand flame cutting equipment is the new welding and cutting torch introduced by the *Hamilton Tool Co.,* Ninth St. at Hanover, Hamilton, Ohio. Its flexible head can be revolved through an arc of 180 deg. and will cut metal of thicknesses from 1/32 in. to 4 in. It will cut holes and circles from 3/8 in. to 30 in. in dia. with an accuracy to within 1/64 in. It cuts countersunk holes, and bevels one or both sides of a straight cut in a single operation.

In addition to the flexible head, the torch has a side-opening tip lock-nut which is said to decrease the time required for the insertion or removal of tips. The valves are all constructed as complete assemblies, and may be easily removed from the body of the torch for inspection and repair.

For OUTSTANDING Shaper Performance . . .



Gould & Eberhardt Specify MEEHANITE® Castings

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry Inc.	Providence, R. I.
H. W. Butterworth & Sons Co.	Bethayres, Pennsylvania
Continental Gin Co.	Birmingham, Alabama
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co.	Portland, Oregon
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Vulcan Foundry Co.	Oakland, California
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey
Washington Machinery & Supply Co.	Spokane, Washington
E. Long Ltd.	Orillia, Ontario
Otis-Fensom Elevator Co., Ltd.	Hamilton, Ontario
U. S. Challenge Co.	Centerville, Iowa and Batavia, Illinois

"This advertisement sponsored by foundries listed above."

HAVING developed and manufactured Shapers for more than ninety-five years, Gould & Eberhardt, Incorporated, Irvington, New Jersey, recognize the importance of selecting the right component material in translating superior engineering design into superior performance.

The production sequence from idea-to blue-print-to manufacturing procedure-to final better service in customers' plants is of special importance not only to the manufacturers of machinery and machine tools but to the users of them.

The function of castings in this sequence is particularly a vital one today and the type, quality, and engineering characteristics provided by better castings can mean the difference between outstanding leadership and quality in the field or a mediocre product.

Meehanite castings are used for the eight major parts of the Gould & Eberhardt 32″ Industrial Shaper illustrated. The internal crank mechanism comprising main lever, crank plate, and bull gear, also are Meehanite castings. The eleven Meehanite castings used in this shaper contribute the superior engineering characteristics necessary to provide in proper combination better wear, high strength, toughness, dimensional stability, rigidity, machinability, and finish.

For the complete details of the engineering properties and industrial applications of Meehanite castings, write for the Meehanite Handbook.

MEEHANITE®

PERSHING SQUARE BUILDING · NEW ROCHELLE, N. Y.

MORE and more important fabricators, who regularly specify Murex electrodes to obtain superior welds, are discovering there are extra dividends when M & T accessories are on the job too.

Top quality M & T holders, helmets, shields, connectors, cleaning tools, protective clothing and other essentials in the line are worthy teammates of Murex with proved performance records. Together they provide improved, safer, more economical, speedier welding.

Write for literature describing M & T arc welding accessories in detail.

METAL & THERMIT CORPORATION

120 BROADWAY • NEW YORK 5, N. Y.

ALBANY PHILADELPHIA PITTSBURGH CHICAGO
SO. SAN FRANCISCO NEWARK CINCINNATI MINNEAPOLIS
HOUSTON TORONTO

MUREX WELDING ELECTRODES
M&T ELECTRODES and GAS RODS
M&T WELDING ACCESSORIES

METAL & THERMIT CORPORATION
120 Broadway, New York 5, N. Y.

Gentlemen:
Please send my copy of "Arc Welding Accessories."

NAME_____TITLE_____

COMPANY_____ADDRESS_____

CITY_____STATE_____

New Finishing Products

Primerless Air-Dry Coating

Easy application, without primer, increased corrosion resistance, and durability are among the features claimed for a new coating of *Lithgow Corp.*, 333 W. 40th Place, Chicago 9. It is for use in tanks, fermenters, carbonated beverage equipment, driers, pipe fittings, filter bodies and bottling equipment.

The new coating is based on inert synthetic resins. It may be sprayed, dipped, flowed, roller coated, or brushed on almost any clean, unpolished, de-rusted surface. It is resistant to acids, alkalies, chlorides, oils, salts, oxygen and alcohol solutions. Electro-chemical corrosion is inhibited by its high dielectric strength. It contains no vegetable oils causing oxidation, or deterioration with age. It is odorless and tasteless.

Baked Aluminum Finish

Development and production of a new and baked aluminum mono-lacquer has been announced by the *Multi-Coat Corp.*, Bedford Glens Rd., Bedford, Ohio. The coating is expected to have application for such products as: machinery, small tools, heavy metal production parts, wheel rims, steel wall panels, pipe fittings, railroad cars, trucks, interior and exterior decorative trimming, toys, kitchen cabinets, store fronts, etc. This paint can be applied to any clean ferrous surface whether or not it has been treated previously with a phosphate coating.

Spray or dip methods can be used for application as well as flow-coating and roller coating. When sprayed or dipped, the paint should be reduced 10% with xyol, toluol, or lacquer thinner. Both flow- and roller-coating are accomplished without reduction. The manufacturer can make variations of this aluminum paint to fit special temperature or time cycle, whether baking is by infra-red or by atmosphere ovens.

Cold Paint Stripper

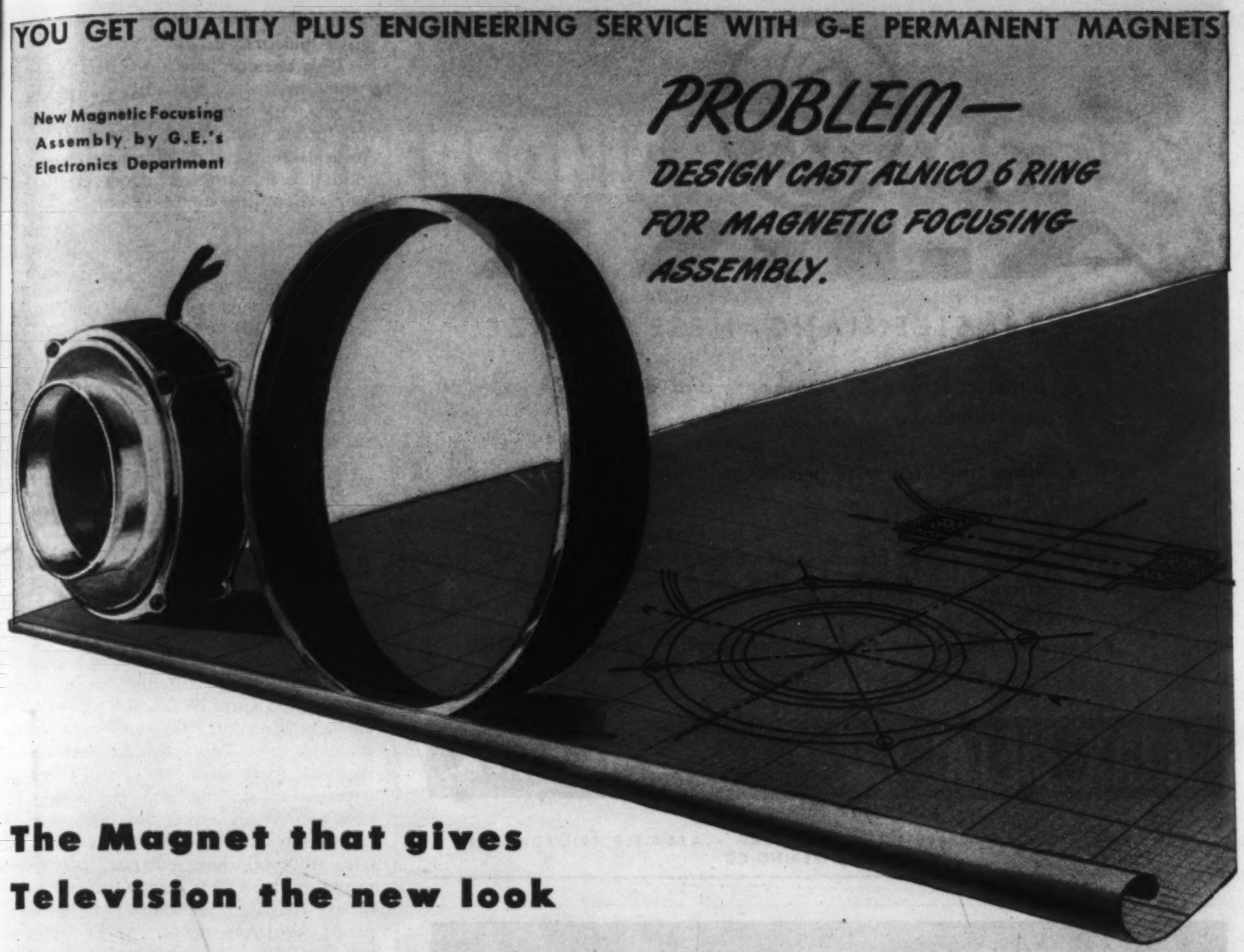
The formulation of a new improved cold paint stripper has been accomplished by the *Allied Finishing Specialties Co.*, 2639 W. Grand Ave., Chicago. The new finish requires no heat and is non-flammable. It removes paints, lacquers, enamels, synthetics, varnishes and wrinkles, and requires no neutralizing action other than a pressure water flushing or wiping well with a rag. Refinishing can then proceed immediately.

The makers claim that the product is non-injurious when used as directed and that it will not affect aluminum, copper, brass, magnesium, zinc, steel, cast iron or their alloys in the time required for removal of the paint film. The stripper is primarily intended for dipping but may be applied by either brush or spray. It works well on either verticle or horizontal surfaces.

Heat-Cured Rack Coating

A single-dip heat-cured rack coating has been introduced by *Michigan Chrome & Chemical Co.*, 6340 E. Jefferson Ave., Detroit 7. It is a 100% solids coating that produces a tough, smooth, leather-like coating with a single application. It withstands all commonly used plating solutions,

YOU GET QUALITY PLUS ENGINEERING SERVICE WITH G-E PERMANENT MAGNETS


New Magnetic Focusing Assembly by G.E.'s Electronics Department
PROBLEM—
DESIGN CAST ALNICO 6 RING FOR MAGNETIC FOCUSING ASSEMBLY.

The Magnet that gives Television the new look

Now it's permanent magnets for better television reception. The permanent magnet shown above keeps electrons on the beam . . . eliminates blurring of the television picture. Once the set has been focused further adjustments are unnecessary. And, the use of a G-E permanent magnet results in greater efficiency since no heat is generated by the Cast Alnico ring magnet.

An outstanding feature of this ring magnet is the very thin wall section developed by G-E process engineers. Heretofore this was possible only with sintered magnets. Better permanent magnets as well as new applications are constantly being developed by G-E engineers.

Perhaps you can improve the efficiency of your product with G-E permanent magnets. General Electric will be glad to work with you to improve your product. Greater flexibility of magnet design is possible with the many G-E permanent magnet materials now available. All are produced under rigid quality control methods. This assures you of receiving magnets of the highest uniform quality for your application.

Clear, sharp television reception with the new G-E Magnetic Focusing Assembly.

The magnetic field set up by the assembly focuses the electron beam on the television screen. The combined effect of the G-E Cast Alnico 6 permanent magnet and a small coil produces this magnetic field axial with the tube neck. The ring magnet supplies the bulk of the magnetic flux while the coil acts as a vernier adjustment. The punched pole pieces collect the magnetic flux and direct it into a uniform radial pattern.

Outstanding advantages of this new assembly are increased efficiency and compactness. Defocusing due to line voltage fluctuation and warm-up drift is eliminated.

METALLURGY DIVISION
CHEMICAL DEPARTMENT, SECTION CN7
GENERAL ELECTRIC COMPANY
PITTSFIELD, MASS.

Please send me:

☐ Bulletin CDM-1, "G-E Permanent Magnets."

Name..... Title.....

Company.....

Products Mfrd.....

Address.....

City..... State.....

PERMANENT MAGNETS

GENERAL ELECTRIC

CD48-V3

AJAX

HIGH TENSILE MANGANESE BRONZE

- *high in strength, toughness and corrosion resistance . . . . . .*
- *long time favorite with manufacturers of marine fittings . . . . . .*
- *leaves sand clean and bright—takes a mirror-like finish . . . . . .*
- *recognized as the highest quality manganese bronze available . . . . . .*

AJAX METAL CO. PHILADELPHIA 23, PA.

ASSOCIATE COMPANIES

AJAX ELECTRIC • AJAX ELECTROTHERMIC CORP. • AJAX ELECTRIC FURNACE
AJAX ENGINEERING CO

Here is nationwide, streamlined service in high-quality specialty steel wires. You get fast action from any of the Johnson offices across the country .... sure of the highest quality when you specify JOHNSON. With an unfailing supply of premium steel. . . . controlled grain structure .... restricted analysis.

Warehouse stocks —Worcester, Chicago, Los Angeles.

JOHNSON

STEEL AND WIRE COMPANY, INC.
WORCESTER 1, MASS.

New York Philadelphia Cleveland Detroit Akron Chicago
Atlanta Houston Tulsa Los Angeles Toronto

acids, and caustics, is non-porous, and has high dielectric strength.

Only one coat is required over the primer which, it is said, will often outlast the life of the rack itself. The good adhesion of the prime coat, which is also impervious to acids and caustics, eliminates contamination due to carry-over from capillary action. According to the manufacturer, racks are completely processed, ready for use, in approximately 2 to 4 hr.

Spraybooth Coating

A spraybooth coating that prevents the sticking of all types of finishes—lacquer, oil paints and varnishes, baking enamels, asphaltums—has been announced by *International Products Corp.*, N. Y. & Ferrier Aves., Trenton 1, N. J. It may be sprayed or brushed on. It dries to a cream-colored light reflecting surface and does not rub off easily when brushed against. It does not settle on standing, is non-corrosive, non-toxic and non-inflammable.

Coating for Metals and Plastics

Development of new coatings for plastic products, as well as a new baking enamel for Masonite and metal products, such as furniture, shelving, and toys, has been announced by the *Monroe Sander Corp.*, Long Island City, N. Y. This new baking enamel, according to the manufacturer, produces a smooth, glasslike surface, and requires about half the time previously needed for sanding and polishing. The new finishes are especially suited for coating plastic materials, such as cellulose acetate, ethly cellulose, butyrate, polystyrene, phenol-formaldehyde and urea-formaldehyde. They can be adapted to individual plant requirements for either spraying, brushing, dipping, or tumbling.

Pit Type Furnace with Lithium Atmosphere

A lithium atmosphere pit type furnace has been designed by the *Lithium Co.*, 111 Sylvan Ave., Newark 4, N. J., for heat treatment of such products as sheet metal, tubular shapes, bar stock, shafts, forgings, coiled wire, connecting rods, gears, engine parts, rolled screw blanks, bearing race stock, machine parts, etc. It is said to eliminate atmosphere variables that cause irregularities in carburizing or heat treatment results.

The unit is designed for heating operations up to 2000 F, providing controlled conditions for carburizing, carbon restoration, annealing, neutral hardening, cycle annealing, normalizing, and descaling. The accurate control of the process makes it possible to replace carbon in the surface of decarburized steel within 5 points of the base carbon of the parts being treated. This furnace provides for carburizing at the rate of 0.020 in. for the first hr., and 0.010 in. thereafter up to 0.125-in. total depth of case.

Lithium vapor, with a standard carrier gas, is introduced into the furnace, filling the work chamber and thereby providing protection and control at the work. The lithium vaporizer unit, in which the lithium

SPERRY ANNOUNCES
A NEW SUPERSONIC REFLECTOSCOPE

For Rapid and Accurate Non-Destructive Testing of Metals
AND OTHER MATERIALS

MAXIMUM IN
PRACTICABILITY
at greatly reduced cost

The new Model SR05 Supersonic Reflectoscope can be used in all the variety of applications possible for the previous model. Smaller, lighter, and more compact, it provides:

***SIMPLIFIED OPERATION—fewer external controls.**

***RUGGED, PORTABLE CONSTRUCTION—can be carried right to the job, in shop or field.**

With the Reflectoscope it is possible to find smaller *defects at greater depths* (up to 10 feet) than with any other non-destructive testing equipment. Cracks, voids, laminations and other defects *are accurately located* in billets, forgings, castings, etc., or in assembled shafts, axles, and other parts.

Write for a *new* bulletin, #3001 F-1, describing the Model SR05 Reflectoscope.

SF-128

TYPICAL APPLICATIONS

Testing welds using the revolutionary angle beam transmission. Ask for Data Sheet 3021.

Testing turbine blanks to ensure freedom from even the smallest of internal defects.

Testing a 17-ft. long aluminum alloy aircraft spar by moving the searching unit over the spar end.

Testing an assembled locomotive axle for fatigue cracks. Safety is increased and maintenance costs reduced.

SPERRY **SPERRY PRODUCTS INC.** HOBOKEN, N.J.
FOR 20 YEARS SPECIALISTS IN NON-DESTRUCTIVE TESTING

Luster-on* makes your zinc plate shine — and stay that way

Luster-on bright dip gives zinc a long-lasting bright finish, proofed against rust and white corrosion.

Luster-on bright dip on zinc doesn't affect spot welding or soldering.

Luster-on bright dip on zinc increases a product's service expectancy and user satisfaction.

Luster-on bright dip on zinc is a cold, quick, non-electrolytic process, speeds production.

Luster-on bright dip on zinc eliminates finger prints and handling marks on assembly.

Luster-on bright dip on zinc maintains the "sales appeal" of articles stored or handled.

Luster-on bright dip on zinc costs only half as much as cadmium and is superior to it.

Luster-on bright dip on zinc is the quick, economical finish for radio, electrical, machine, automotive and ventilation parts, builders' hardware, hand tools, fasteners, sporting goods and toys.

We want to prove these statements to you. We want to show you *why* Luster-on is first in its field, *how* it's first in results. Send us a sample for free processing. We'll give it the Luster-on treatment, and tell you the full story on how it's done. No obligation, of course.

83

*Reg. U.S. Patent Office

THE Chemical CORPORATION

54 Waltham Ave., Springfield 9, Mass.

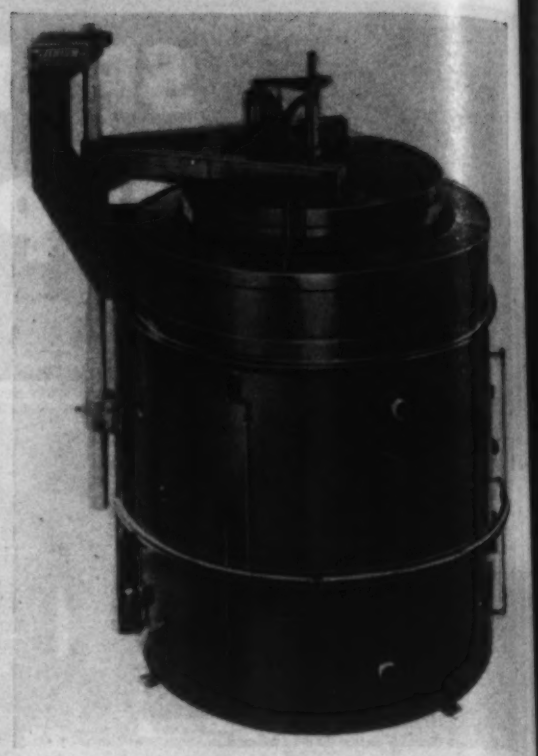
THE CHEMICAL CORPORATION
54 Waltham Ave., Springfield, Mass.

Please send me full particulars about Luster-on* bright dip for zinc-plated surfaces. I am (am not) sending sample for free dip. No obligation, of course.

Name _____

Firm _____

Address _____



This pit type furnace uses a lithium atmosphere for protection of work during the heat treating cycle.

cartridge is heated, is built integrally with the furnace, and is heated independently by either gas burners or electric heating elements. The cost of the lithium used in this furnace is less than 2½¢ per hr. The furnace is equipped with an alloy retort into which the work is placed. Arrangement can be made to either suspend the work vertically from a fixture or be loaded in baskets, whichever is more desirable.

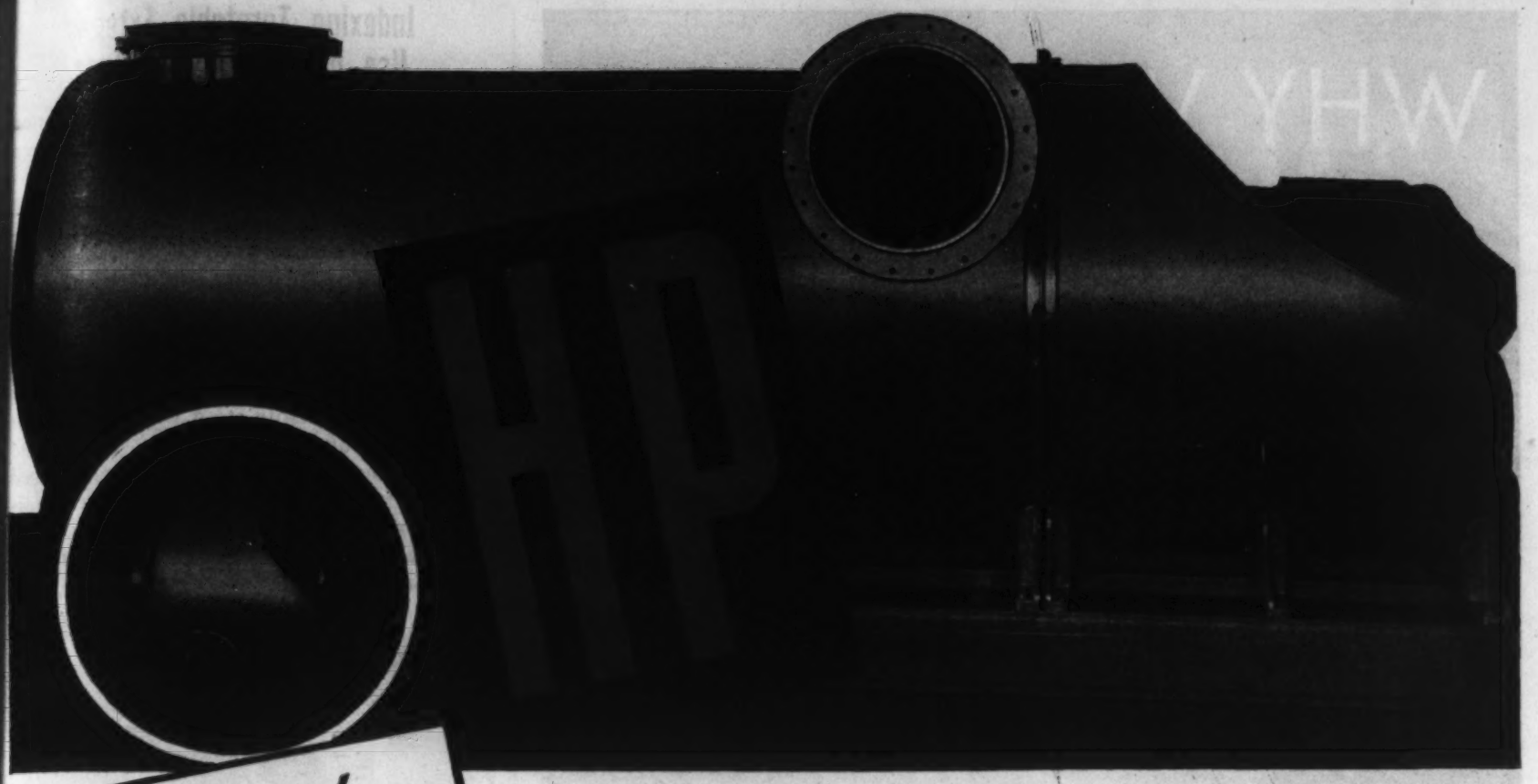
Lithium atmosphere pit type furnaces are made in 14 standard muffle sizes, with work areas from 20-in. dia. by 20 in. deep to 36 in. by 60 in. (and larger special sizes), for a wide range of varying size, shape and number of pieces.

● A new instrument, known as the Measure-Scope, measures angles to within 1 sec. of arc, and length to two-millionths of an in., with an accuracy of 0.1% of full scale. The instrument is manufactured by the *American Instrument Co., Inc.,* Silver Spring, Md.

Die Life Increased with New Bronze Alloy

A new aluminum bronze alloy engineered for use in forming and drawing dies has been announced by *Ampco Metal, Inc.,* Milwaukee 4, Wis. The new alloy is said to have the necessary hardness coupled with high compressive strength and wear resistance to meet the special requirements of this service.

The new material is reported to have two to five times the life of other bronze dies before redressing and many times the life of steel dies. In one instance reported, 3000 heavy gage stainless steel pieces were formed on a steel die while 77,000 pieces were produced on a like die of this new alloy.



1/3 800

ASK FOR THESE BULLETINS

TECHNICAL BULLETIN No. 126
DATA BOOK No. 107
GAS BOOSTERS No. 109
FOUR BEARING No. 110
BLAST GATES No. 122
FOUNDRIES No. 112

You may not need an 800 HP Turbo-Compressor but it is interesting to know that this Spencer machine is delivering large volumes of air at 10 lbs. pressure for engine testing.

The midget Spencer delivers 85 cubic feet per minute at 8 ounces pressure and is used by the hundreds by manufacturers of heat treating, air conditioning and pneumatic tube systems as a part of their finished products.

The Spencer Turbo is distinguished by its simple, sturdy construction, with constant pressure automatically delivered with high efficiencies at all loads.

Quiet operation without vibration is one of the advantages of the Spencer Turbo. This is due to several factors: the multi-stage construction resulting in low peripheral speeds; lightweight perfectly balanced impellers with wide clearances; and a ball bearing supported by a cast bridge work.

SPENCER TURBO APPLICATIONS

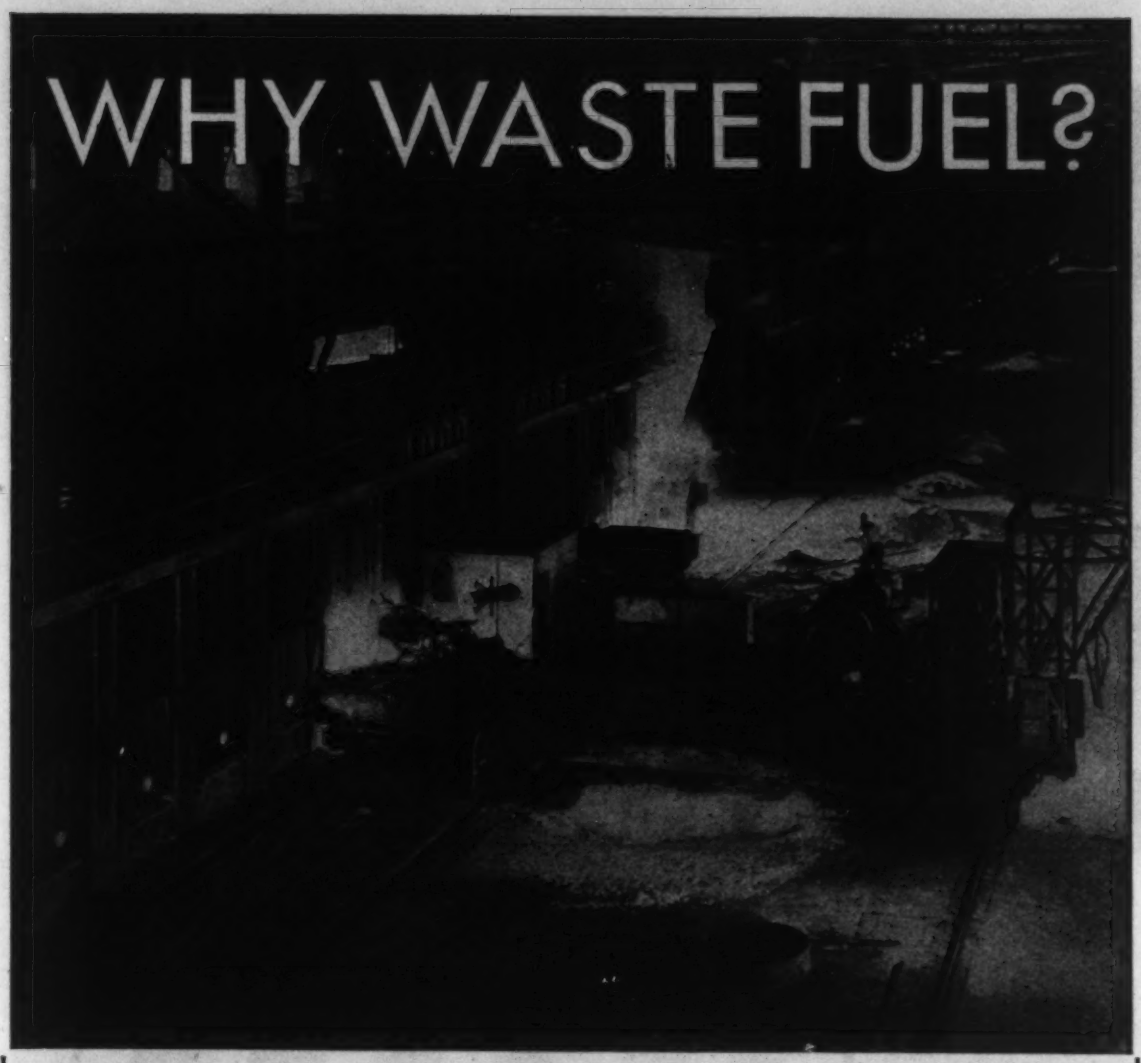
AGITATION • HEAT TREATING • GAS BOOSTERS • VENTILATION

Standard sizes from 35 to 20,000 cu. ft.; ⅓ to 800 HP ; 8 oz. to 10 lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive construction available. Ask for the Turbo Data Book and Bulletins.

359-C

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONN.

SPENCER TURBO-COMPRESSORS



Therm·O·flake *prevents waste*
BY REDUCING HEAT LOSSES...

MORE THAN 25% of Open Hearth fuel can be wasted through heat lost through brickwork and heat absorbed by cold infiltered air.

Therm·O·flake INSULATIONS are designed to reduce heat losses and seal furnace walls against cold air infiltration. These are used regularly on hundreds of open hearth furnaces and save steel producers thousands of fuel dollars daily.

Therm·O·flake ENGINEERS will prepare an accurate fuel economy survey of existing furnaces in your plant and submit complete thermal data and recommendations for safe maximum insulation of any open hearth furnace, on request.

Illinois Clay Products Company
JOLIET, ILLINOIS

Exclusive Manufacturers of
Therm·O·flake
open hearth Insulation

Indexing Turntable Extends Use of Induction Heaters

An indexing turntable for induction soldering, brazing or heat treating has been developed by *Sherman Industrial Electronics Co.*, 505 Washington Ave., Belleville 9, N. J. Work pieces are placed either manually or automatically on work holders and all operations thereafter are electrically and air controlled. As many as 12 work stations can be provided on the standard turntable top.

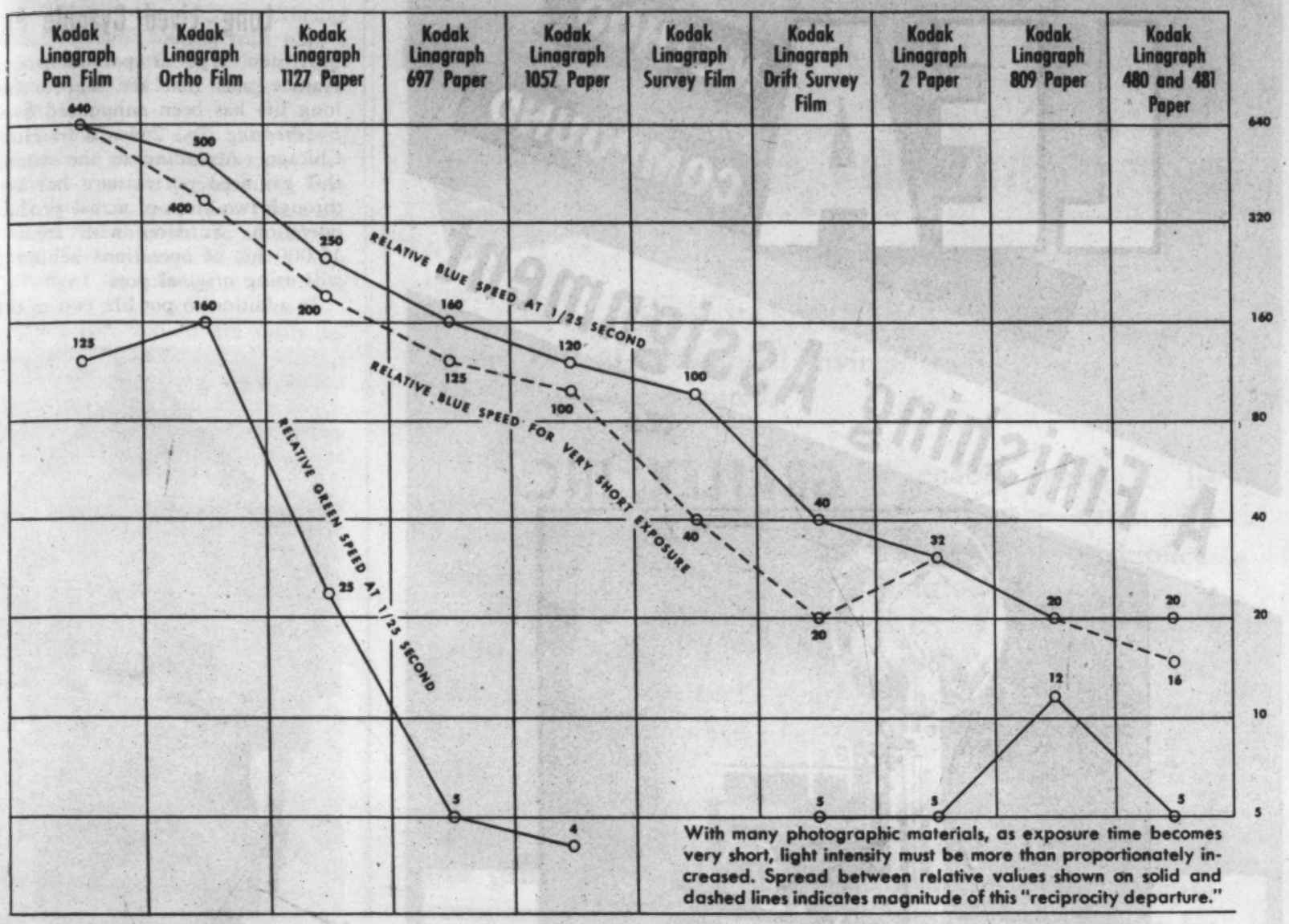
Holding jigs to fit special work piece shapes are available from the manufacturer or may be added by the user. The formed metal cabinet is of heavy gage steel, finished in machinery grey crackle. Leg room is provided for the operator's comfort.

Heating time of 1 to 60 sec. is controlled by an adjustable electric timer. Limit switches and electric air valves insure proper sequence of operation. Air pressure regulator, oiler and filter are part of the standard unit.

As many as 12 work stations can be provided on this induction heating turntable.

Modified forms of the standard unit are available. These include non-indexing turntables for continuous travel of work pieces through tunnel type coils and also jet quench attachments for hardening applications. Operation requires 60-lb. air supply and 220-v., 60-cycle, single-phase power.

● A new line of industrial finishes, especially developed for household appliance products, has been announced by the *Sherwin-Williams Co.*, Cleveland. The new finishes feature greater ease of application, with excellent opacity and build; economy of application; range of baking adaptable to numerous types of products; improved color stability and retention; greater resistance to fruit acids, beverages, food and alkali; good adhesion; hard, tough, durable and marproof finished surface; and resistance to humidity and soap-water immersion.



With many photographic materials, as exposure time becomes very short, light intensity must be more than proportionately increased. Spread between relative values shown on solid and dashed lines indicates magnitude of this "reciprocity departure."

Here's how to find the right recording material

. . . New FREE folder gives full information about speed and other factors to consider in selecting the best Kodak Linagraph film or paper for any job.

Do you know that there is a new high speed Kodak Linagraph paper that makes possible the recording of fast cathode-ray traces directly on paper . . . for easy handling . . . for easy pencil notation?

Do you know that Kodak Linagraph materials include films and sensitized papers for recording transient blue traces . . . repetitive green traces . . . galvanometer light beams . . . a film that can be exposed at 300° F. . . a sensitized paper with an abrasion-resistant emulsion?

Do you know that you can order any of 168 *different* combinations of paper characteristics and sizes . . . with a wide selection of spools and cores, in addition?

The easy way to get full information on Kodak Linagraph materials . . . including an enlarged version of the helpful chart above . . . is to send in this coupon.

INSTRUMENT RECORDING

. . . another important function of photography

Eastman Kodak Company, Rochester 4, N. Y.

EASTMAN KODAK COMPANY
Rochester 4, N. Y.
Please send me your new folder
on Kodak Linagraph Recording Materials.

Name_____ (please print)

Organization_____

Department_____

Address_____

City_____

State_____

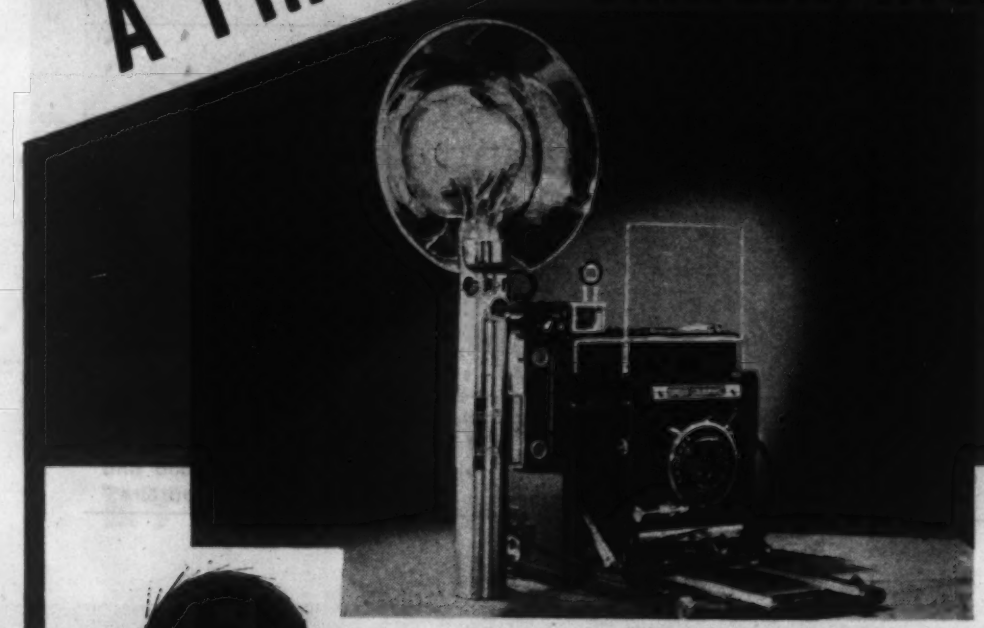
"Kodak" is a trade-mark

Kodak

LEA METHOD COMPOUND

A Finishing Assignment

GRAFLEX, INC.



The famous Speed Graphic Camera

Graflex, Inc., manufacturers of famous photographic equipment since 1890, have found in the proper LEA Method and LEA Compound the solution to a difficult finishing problem on the yoke of the famous Speed Graphic.

LEA's work at Graflex, Inc. is another example of the wide versatility enjoyed by LEA Methods and LEA Compounds. If you are burring, polishing or buffing metals, plastics or woods, you should consult a LEA Finishing Engineer. He may be able to assist you in cutting costs, cutting production time and in improving the quality of finish on your products.

THE LEA MANUFACTURING CO.

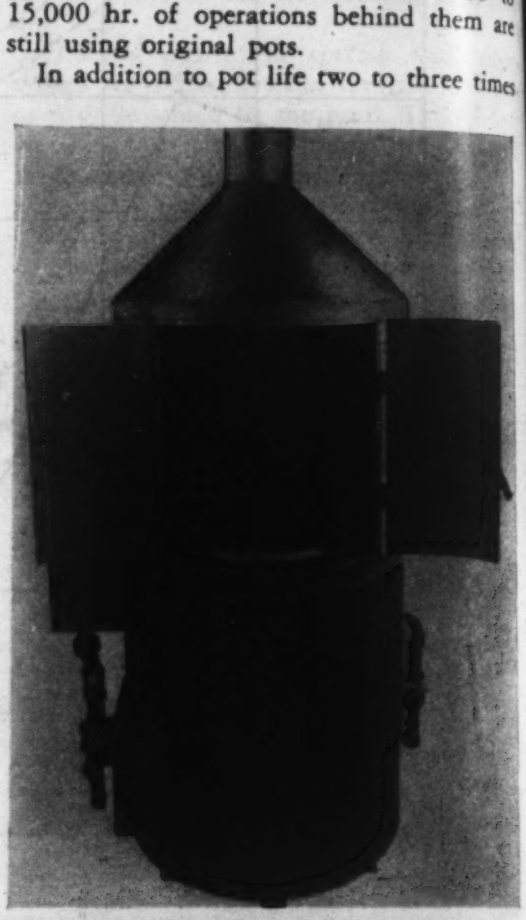
16 CHERRY AVENUE • WATERBURY 86 • CONNECTICUT

7-LM-3

Pot Furnace Has Long-Lived Cyanide Pot

A new type of pot furnace featuring cyanide pots that are said to have extra long life has been announced by *Lindberg Engineering Co.*, 2444 West Hubbard St., Chicago. According to the manufacturers, this gas fired pot furnace has been tested through two years of actual production line operation. Furnaces with from 8000 to 15,000 hr. of operations behind them are still using original pots.

In addition to pot life two to three times



This gas fired pot furnace features a guarantee of long life.

better than previous figures, the manufacturer claims faster heating and greater efficiency. The furnace is available in four standard sizes using pots 24 by 21 in.; 20 by 21 in.; 16 by 18 in.; and 12 by 18 in.

Roll Coating Machine Has Wide Range of Use

A new roll coating machine should prove interesting to manufacturers, whose processes include coating of flat material with drawing compound, oil, glue, sizing, wax, paint or lacquer. This unit is now offered by *Columbia Machinery & Engineering Corp.*, Hamilton, Ohio.

These machines have 10-in. coating rolls and 8-in. doctor rolls. Large coating rolls reduce the angle of departure from the work, providing a more uniform spread, and the larger crotch affords greater capacity and easier control of coating material spread.

The doctor roll normally turns at a speed much slower than that of the coating roll. This difference in roll speed produces a

(Continued on page 119)

wiping action that contributes to evenness of spread. Depth of spread is set and maintained by adjustment of calibrated handwheels. Standard coating rolls have a corrugated rubber surface with circumferential grooves, 0.025 in. deep, spaced 20 to the in.

Coating and doctor rolls are driven through a positive chain-and-sprocket drive and geared-head motor. Standard drive speed is 75 lineal ft. per min., but other speeds may be had through use of variable speed drives. Surface speed of doctor rolls may be changed by changing the drive sprocket.

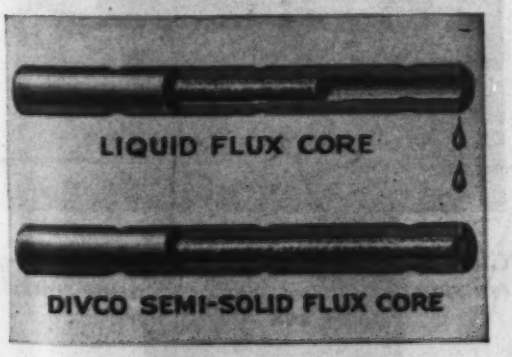
Rolls, tables and troughs are easily removed for cleaning. The infeed table is solid, while the off-bearing table has a number of adjustable pick-off fingers of improved design. Down-pressure on safety bars running the full length of the machine stops and reverses the rolls.

The coating machines are regularly made in four rolls arrangements for coating one or both sides of the material, and in roll sizes from 32 in. to 104 in. (by 6-in. increments) for handling material up to 102 in. wide. Material up to 4 in. thick can be accommodated.

New Acid Core Solder with Non-Liquid Flux

A heavy flux that remains non-fluid and will not run out at normal temperatures is now being used in a core solder produced by *Division Lead Co.*, Dept. 107, 836 W. Kinzie St., Chicago 22. This flux does not take on moisture from the air. When heat is applied, it flows freely, spreads and penetrates quickly, producing effective fluxing action.

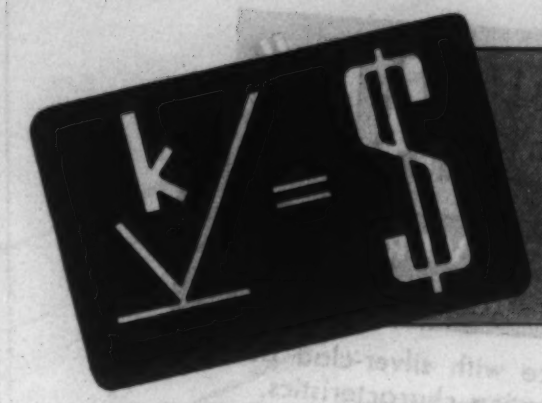
It works well on all solderable metals, including stainless steel, Inconel, nickel, and other hard-to-solder metals. It is furnished in standard spool sizes and popular



The non-liquid flux as shown does not leak out.

grades and sizes. There are also solder washers and segments cut and pre-formed to specifications.

The advantages of pre-cut and pre-formed cored solder segments are said to be greatly increased by this new, non-liquid flux because the flux stays put, assuring uniform fluxing action and dependable soldering results.



A NEW EQUATION *in* PRODUCTION PROFITS

CONSTANT SURFACE ROUGHNESS
is the key to substantial savings in progressive plants throughout the country.

Modern roughness control enables parts to be brought more rapidly to final size and finish—often with fewer operations. It saves time in setting up for duplication of previous jobs on both long and short runs. It permits impending *dimensional* errors to be detected *before they occur,* so that such errors can be prevented and rejects eliminated. And by no means incidentally, it improves the quality of product.

The closeness of control required cannot be obtained by visual inspection; for differences in reflectivity, lay of the grind or curvature of the work prevent accurate comparison with roughness specimens. Inspection by "feel" is likewise subject to serious human error.

To eliminate errors of judgment—to obtain the dependable accuracy of measurement essential to effective control—more and more companies are using the Profilometer as a regular part of their quality-control equipment.

The Profilometer gives *definite, accurate and consistent microinch readings.* It is ruggedly built for shop use, and is portable—can be used wherever most convenient. It will measure practically any surface that can be produced by machining, grinding or finishing operations—and it's very simple to operate.

Write for complete information—and arrange for a demonstration in your own plant. You may be surprised to learn the many ways in which this instrument can save you money.

The PROFILOMETER
TRADE NAME REGISTERED

PRC PHYSICISTS RESEARCH COMPANY

ANN ARBOR • MICHIGAN

"SILVER-CLAD"

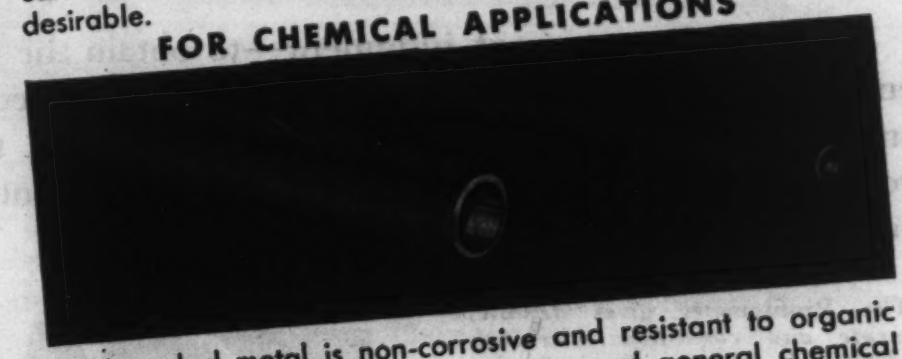
THE COST SAVING, VERSATILE LAMINATED METAL

Save on costs, gain in performance with silver-clad base metals which offer a diversity of operating characteristics.

FOR ELECTRICAL APPLICATIONS

A part made from silver laminated to a base metal makes an ideal electrical contact. The essential electrical properties of the silver alloy are obtained at minimum cost. At the same time, the most advantageous characteristics of the desired base metal can be utilized. Many engineers feel the most important feature of silver-clad is the absence of a mechanical bond between silver and base metal. Typical examples of the advantage of silver-clad material are found in parts made from silver on phosphor bronze or nickel silver where spring temper is required in the blade, this spring to be obtained by work hardening. We can supply these laminated metals in any temper. For special uses, silver or beryllium copper may be formed soft, then hardened to maximum strength and spring temper. For rugged construction, where heavy loads are carried, silver on pure copper is generally considered most desirable.

FOR CHEMICAL APPLICATIONS



Silver-clad metal is non-corrosive and resistant to organic acids. For food processing equipment and general chemical usage, we have developed new tubing. It may be silver-clad on the inside, or outside, or both, in lengths up to 20 feet, and diameters up to 1 1/2 inches. If demand warrants, diameters of 2 or more inches could be made. The precious metal ratio is closely controlled, the silver surface is hard and free from porosity, and it is economical.

Any alloy of silver will be furnished upon request. Your further investigation is invited. Our chemists, metallurgists, and sales engineers are at your service.

START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS • FABRICATED PARTS AND ASSEMBLIES

D. E. MAKEPEACE COMPANY

Main Office and Plant, Attleboro, Massachusetts

NEW YORK OFFICE, 30 CHURCH ST. • CHICAGO OFFICE, 55 EAST WASHINGTON ST.

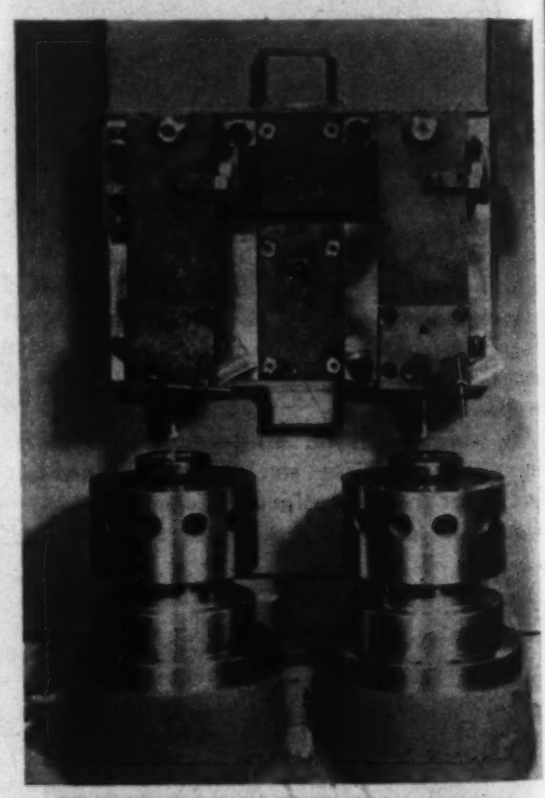
High Production Boring Machine Uses Carbide Boring Bars

A high production precision boring machine designed specifically for the use of solid cemented carbide boring bars has been announced by *Hoern & Dilts, Inc.*, 925 Rust Ave., Saginaw, Mich. The cemented carbide boring bars were developed by Carboloy Co., Inc., Detroit 32.

The new model is a five-station, ten-spindle machine with a cemented carbide boring bar for each work spindle. Standard carbide boring bits are inserted in each carbide boring bar. The head of the machine is pentagonal, each side carrying two boring bars.

In operation the head and work table revolve continuously. Work spindles stop turning at the loading station, the boring bars also retracting. The spindles again start automatically when the loading station has been passed.

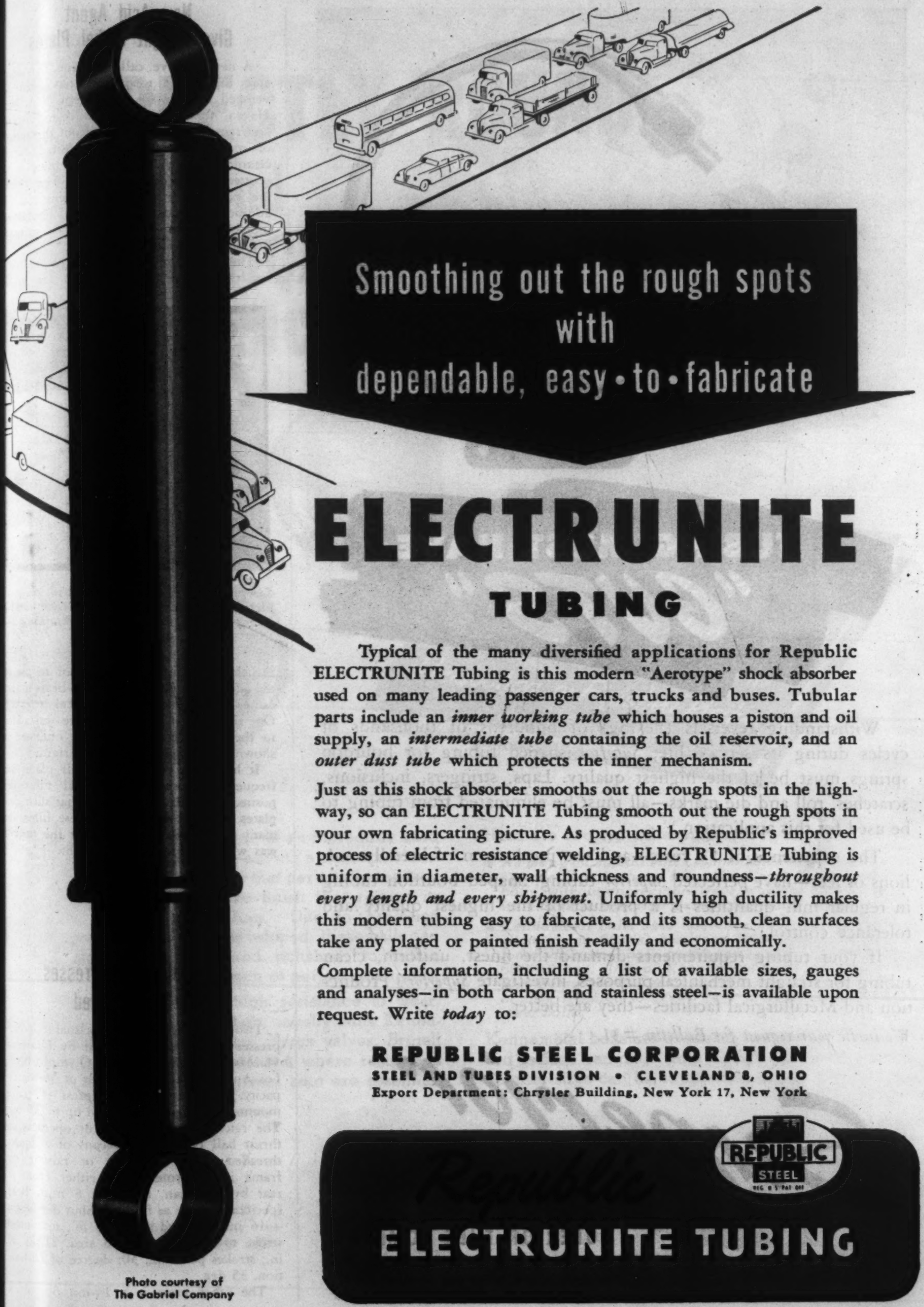
Chief advantage claimed for the carbide boring bars is their ability to bore parts of greater lengths-to-diameter ratios with greater accuracy. This is possible because high rigidity of the carbide bar reduces both deflection and "wind-up." Thus, in one case, valve guides of 6:1 length to dia. ratio are being bored to a precision of 0.001 in. on dia. and 0.0002 in. for alignment and concentricity. The production rate ranges from 1400 pieces per hr. for pieces having a depth-to-diameter ratio of 6 to 1, to 800 pieces per hr. for guides bored from each end.



Close-up of one station of the five-station, ten-spindle boring machine using carbide tools and boring bars.

Spindle and work table speeds are changed by means of interchangeable V-belt pulleys in the drive from the main 10-hp., 1800-rpm. spindle drive and the 2-hp. table drive motors. Table and head are supported on radial and thrust roller bearings on the machine column.

Capacity of work is 6 in. max. O.D. and ¼ in. min. I.D. Maximum boring depth on the standard machine is 5 in.



Smoothing out the rough spots
with
dependable, easy • to • fabricate

ELECTRUNITE
TUBING

Typical of the many diversified applications for Republic ELECTRUNITE Tubing is this modern "Aerotype" shock absorber used on many leading passenger cars, trucks and buses. Tubular parts include an *inner working tube* which houses a piston and oil supply, an *intermediate tube* containing the oil reservoir, and an *outer dust tube* which protects the inner mechanism.

Just as this shock absorber smooths out the rough spots in the highway, so can ELECTRUNITE Tubing smooth out the rough spots in your own fabricating picture. As produced by Republic's improved process of electric resistance welding, ELECTRUNITE Tubing is uniform in diameter, wall thickness and roundness—*throughout every length and every shipment.* Uniformly high ductility makes this modern tubing easy to fabricate, and its smooth, clean surfaces take any plated or painted finish readily and economically.

Complete information, including a list of available sizes, gauges and analyses—in both carbon and stainless steel—is available upon request. Write *today* to:

REPUBLIC STEEL CORPORATION
STEEL AND TUBES DIVISION • CLEVELAND 8, OHIO
Export Department: Chrysler Building, New York 17, New York

Republic
REPUBLIC STEEL
ELECTRUNITE TUBING

Photo courtesy of
The Gabriel Company

Withstanding reversals (flexing) of hundreds of thousands of cycles during its service life, *Superior* shaped tubing for bourdon springs must be of the highest quality. Laps, stringers, inclusions, scratches, roll and die marks—all must be eliminated from tubing to be used for this application.

The experience of 13 years—and the production of literally millions of feet—have perfected *Superior* tubing. Shaped bourdon tubing in regular mill quantities is a product of the highest quality and tolerance control.

If your tubing requirements demand the finest, uniform, clean tubing for straight mechanical purposes, investigate *Superior's* Production and Metallurgical facilities—they are better.

We invite your request for Bulletin #31.

Superior

THE BIG NAME IN SMALL TUBING (.010" TO ⅝" O.D. MAX.)

SUPERIOR TUBE COMPANY

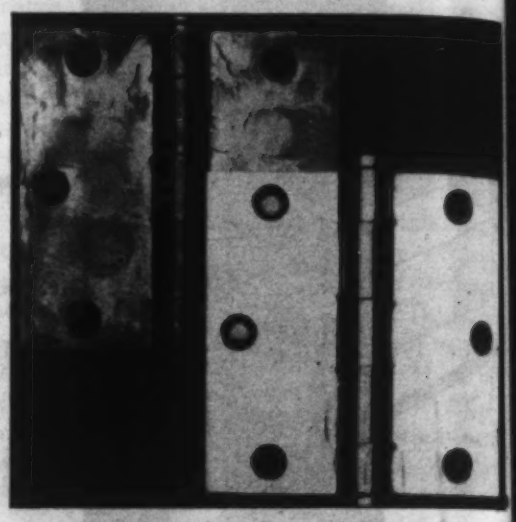
2008 Germantown Ave., Norristown, Pa.

For Superior Tubing on the West Coast, call PACIFIC TUBE CO., 5710 Smithway St., Los Angeles 22, Cal. • ANgeles 2-2151

New Acid Agent Gives Bright Nickel Plates

A new additive, called Actane, for use in acid dips prior to plating has been developed by *Enthone, Inc.*, Dept. MA, New Haven, Conn. Its function is to disperse and remove colloidal films from the surface of metals that may be deposited during cleaning and which cause the plate to be spotted, streaked, or stained. The results are said to be particularly beneficial for additions to acids for dipping of nonferrous metals such as copper and brass prior to bright nickel plating.

The accompanying photograph indicates results obtained in production for bright



Sample on left was acid dipped prior to plating in regular acid dip. Right, sample was processed in acid dip containing the new additive.

nickel plating upon brass. Prior to use of the additive in the acid dip, the brass hinges came out of the bright nickel streaked. One oz. per gal. of the additive was added to the acid dip and the plate obtained is shown by the specimen on the right.

It has been proven that dull plates are frequently caused by colloidal films deposited in alkali cleaners and that such dull plates obtained are due to these films. In many cases it was believed that the trouble was with the bright nickel bath.

Inclinable Punch Presses Are Back Geared

Two new back geared inclinable punch presses have been announced by *Diamond Machine Tool Co.*, 3429 E. Olympic Blvd., Los Angeles, Calif. The one is of 56-ton capacity. The frame in this press is cradle mounted and may be inclined up to 35 deg. The ratchet feed arrangement operates on thrust ball bearings by means of a square threaded screw. Inclining or raising the frame is performed from either front or rear by one man, requiring 8 min. Brief specifications are as follows: Shut die height —16 in.; standard stroke, 3 in.; maximum stroke to order, 8 in.; bed area, 21 by 30 in.; strokes per min., 50; degree of inclination, 35 deg.

The other press is a 14-ton open-back

PERFECTLY ROUND*
and
PRACTICALLY INDESTRUCTIBLE

Compressive strength up to 800,000 p.s.i.

●

Modulus of elasticity 2 to 3 times that of HSS steel.

●

Hardness up to 80.6 Rockwell C.

Kennametal Balls are made of an incredibly hard Kennametal composition, having a uniform, close-grained physical structure that permits the surface to be given a mirror-like finish that retains its lustre, and is non-galling. Due to precision processes that we have developed, these balls can be supplied, ground and polished, to within twenty-millionths of an inch of perfect roundness.

This accuracy, plus high resistance to wear, corrosion, and deformation, ideally suits Kennametal balls for hole sizing, check valves, Brinell testing, and other applications where resistance to abrasive wear, shock, and heat are essential.

Here are two typical examples:

- *As many as 20,000 valve tappet holes in automobile cylinder blocks have been sized with Kennametal balls, without appreciable wear; whereas steel balls wore to undersize after sizing 1,600 holes.*
- *Kennametal balls held tolerance and concentricity while sizing 60,000 hardened steel bushings, 3/4" long; while steel balls on the same job produced only 600 sizings. Use of Kennametal balls practically eliminated rejects, and saved approximately 90% of time required to check gage of holes sized with steel balls.*

Kennametal balls are available in nineteen standard sizes, ranging from 1/32" to 1-11/16". Smaller sizes can be supplied to order.

**To within twenty-millionths of an inch.*

KENNAMETAL

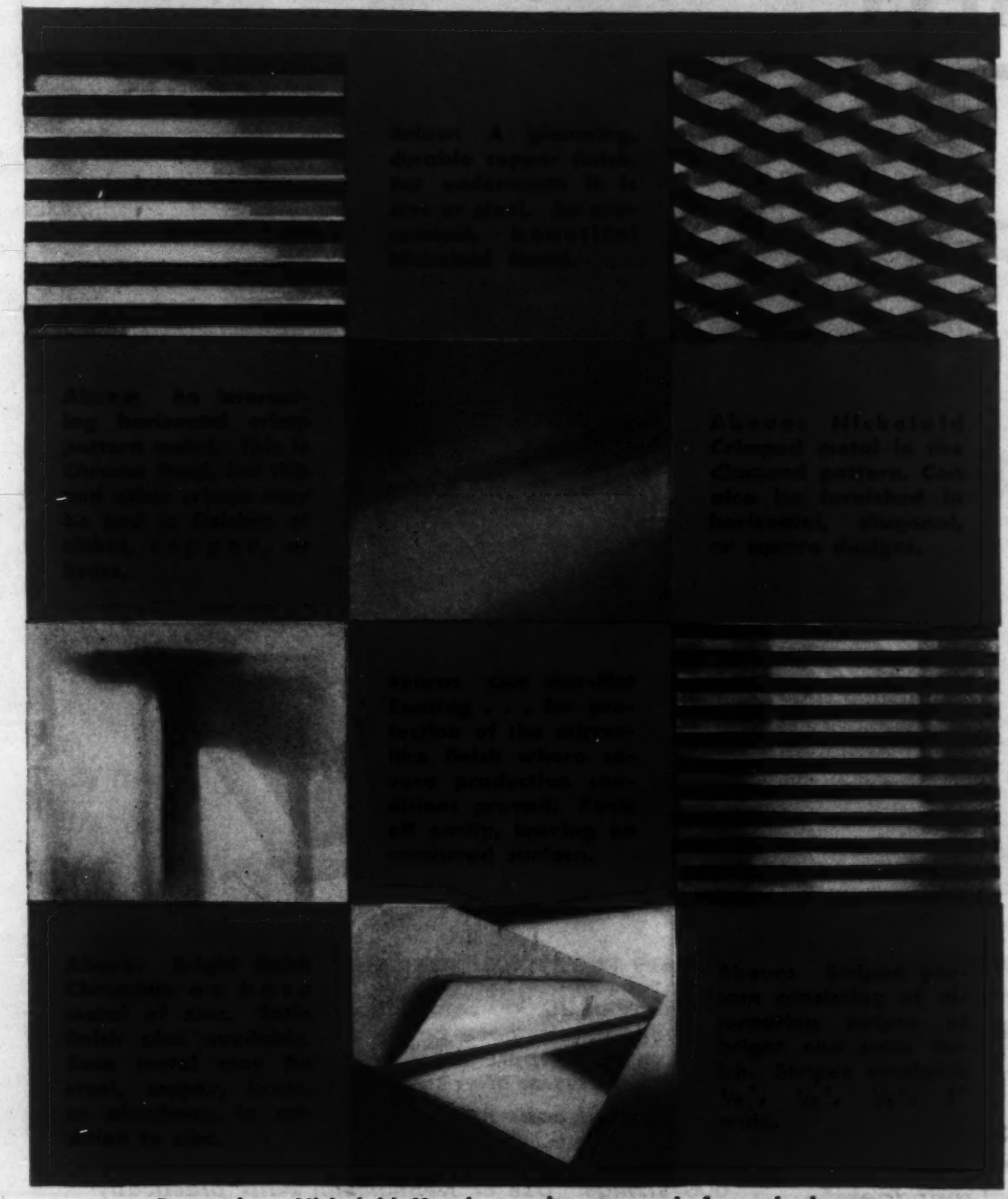
SUPERIOR CEMENTED CARBIDES

TRADE MARK REG U. S. PAT. OFF.

KENNAMETAL *Inc.*, LATROBE, PA.

Designers:

WHAT COULD YOU DO WITH THESE NICKELOID METALS?



Remember, Nickeloid Metals can be stamped, formed, drawn without harming their mirror-like finishes. Available in sheets, coils . . . wide range of sizes, gauges, and tempers.

50 Years of Pre-plated Metal Leadership

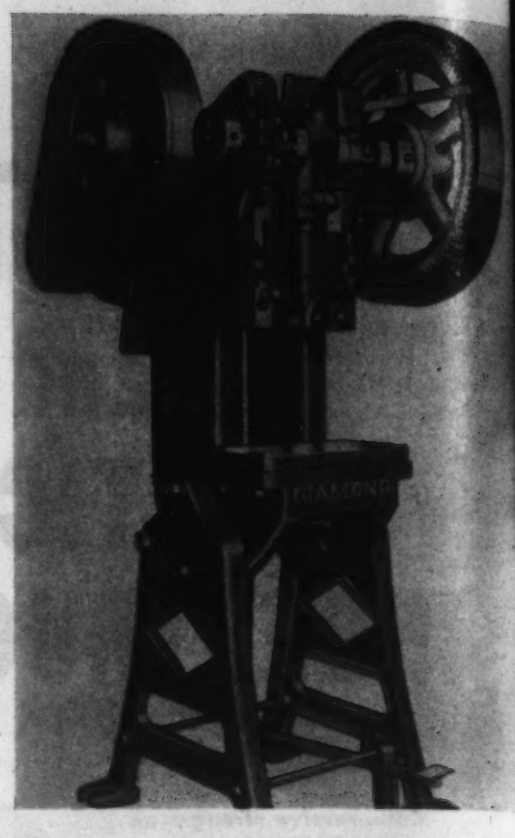
AMERICAN NICKELOID COMPANY

Established 1898

PERU 6, ILLINOIS

NICKEL · CHROMIUM · BRASS · COPPER · ZINC
Electro-plated TO ALL COMMON Base METALS
ALSO LACQUERED COLORS
SHEETS AND COILS

OLDEST AND LARGEST PRODUCERS OF PRE-PLATED METALS



This 14-ton inclinable back geared press is one of the smallest of its type being made.

inclinable geared press. This press is suggested for use wherever the following requirements exist: Approximately 50% less strokes per min.; delivery of rated tonnage over longer length of ram travel; operations with extra long strokes; operations with drawing dies, forming dies and in blanking operations where a large amount of shear is required. It is also recommended with use of dial index feeds.

Specifications of the 14-ton geared press are as follows: Maximum strokes per min., 65; standard length of stroke, 2 in.; maximum length of stroke to order, 4 in.; bed area, 8 by 5 in.; shut die height on No. 14-A is 7 in. and on No. 14-B, 9 in. These presses have a non-repeat single trip mechanism.

Plastic Sheet Stock Offers Low Cost Fabrication

Full production on Styron sheet stock developed for low cost transparent containers has been announced by the plastics division of the *Willson Magazine Camera Co.*, Philadelphia. The sheet is made in thicknesses of 1/16 in., 3/32 in., 1/8 in., and 3/16 in. Because of greatly reduced initial tooling costs and the special Willson manufacturing technique, it is possible to supply this sheet at prices as low as 57¢ per sq. ft.

According to the producers, the economic factor of Styron sheet, together with the plastic's properties of low water absorption, dimensional stability, and mechanical strength as well as other advantageous properties all inherent in the sheet stock, has created a demand for it by manufacturers of parts and units in such fields as refrigeration, fluorescent lighting, display, aircraft, automotive, communications, packaging and many other fields.

Whatever Your Blast Cleaning Problem

PANGBORN Has the Right Equipment for Every Job...

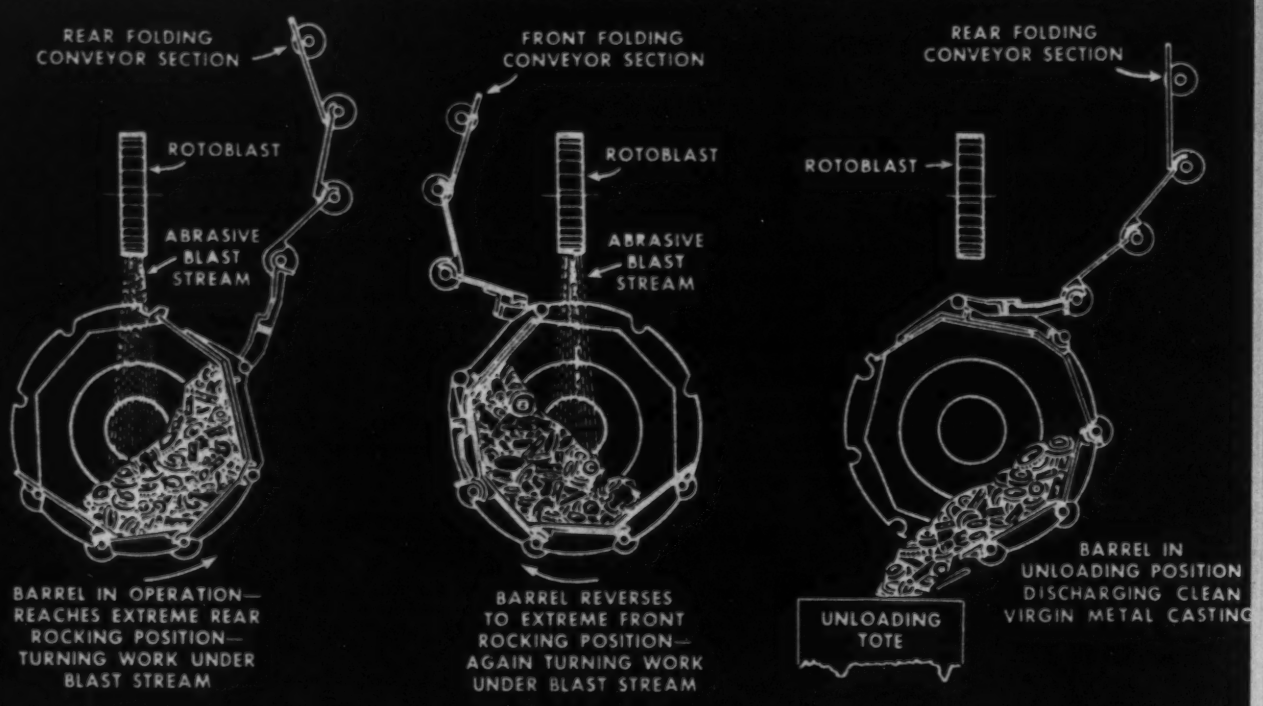
Pangborn ROTOBLAST Barrels

Current users of Pangborn ROTOBLAST Barrels report enthusiastically the savings in man-hours, the increase in cleaning output, the improved consistent uniformity of cleaning, and drastically cut over-all cleaning costs that are directly traceable to these machines. The exclusive design feature of Pangborn Rocking Action has proved to be an efficient way of completely turning work, as well as untangling shapes that tend to interlock or "nest."

AVAILABLE IN CAPACITIES OF 3½, 7, 14, 17½, 21, 28 CUBIC FEET

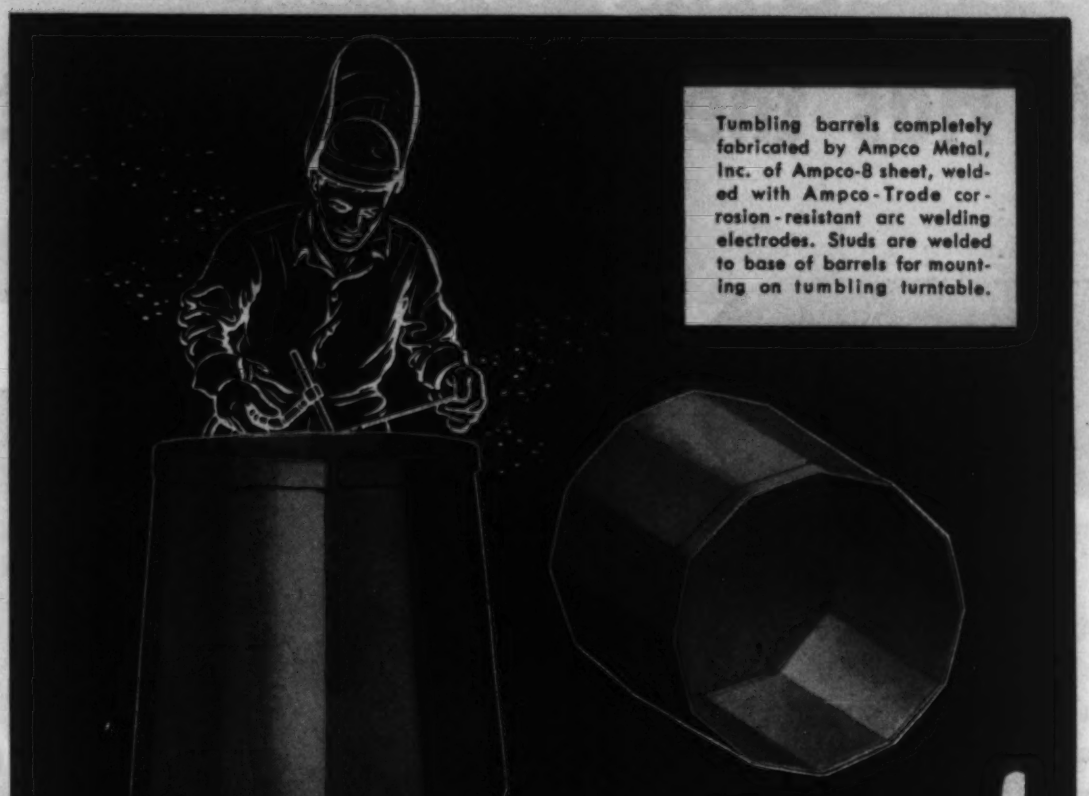
WRITE TODAY for information on all Pangborn Blast Cleaning and Dust Control Equipment. Address: PANGBORN CORPORATION, 1403 Pangborn Blvd., Hagerstown, Maryland.

HERE'S HOW PANGBORN EXCLUSIVE ROCKING ACTION TURNS OUT PRODUCTION


REAR FOLDING CONVEYOR SECTION
ROTOBLAST
ABRASIVE BLAST STREAM
BARREL IN OPERATION— REACHES EXTREME REAR ROCKING POSITION— TURNING WORK UNDER BLAST STREAM
FRONT FOLDING CONVEYOR SECTION
ROTOBLAST
ABRASIVE BLAST STREAM
BARREL REVERSES TO EXTREME FRONT ROCKING POSITION— AGAIN TURNING WORK UNDER BLAST STREAM
REAR FOLDING CONVEYOR SECTION
ROTOBLAST
BARREL IN UNLOADING POSITION DISCHARGING CLEAN VIRGIN METAL CASTING
UNLOADING TOTE

Pangborn

BLAST CLEANS CHEAPER with the right equipment for every job



Tumbling barrels completely fabricated by Ampco Metal, Inc. of Ampco-8 sheet, welded with Ampco-Trode corrosion-resistant arc welding electrodes. Studs are welded to base of barrels for mounting on tumbling turntable.

Ampco Metal

makes tumbler-barrel costs tumble

Using Ampco rolled sheet cuts maintenance and replacements

Tumbling barrels are used to clean rivets, screws, nuts, and a variety of similar small parts. Formerly, they wore out quickly—because of the cleaning solution's corrosive action, and the abrasive effect of swirling metal parts. Replacement costs were high, until the manufacturers switched to tumbling barrels fabricated with Ampco-8 sheet. This durable, corrosion-resistant alloy solved their expensive replacement problem in jig-time.

That is just one more case of the money-saving value of Ampco Metal's unique physical properties. Hundreds of companies use durable Ampco Metal and Ampcoloys in their own products as selling features—and in their production equipment as insurance against heavy maintenance and replacement costs on parts subject to wear.

Call in your nearby Ampco engineer for cost-cutting suggestions. Write for complete information on Ampco castings, extrusions, forgings, sheet, and fabricating service.

Ampco Metal, Inc.

Department MA-7 • Milwaukee 4, Wisconsin

Field offices in principal cities

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Earle C. Smith, chief metallurgist, Republic Steel Corp., was awarded Ohio State University's Lamme Medal for meritorious achievement in engineering at the University's commencement exercises on June 11. Previous medals and awards include those issued by the American Institute of Mining & Metallurgical Engineers and the American Society for Metals. One of Mr. Smith's main achievements has been investigation of the mineralogical constitution of slags and their function in the refining of steel. He was educated at Ohio State and Columbia universities.

John W. Crossett has joined the Development & Research Div., International Nickel Co., Inc., and will follow railroad development work. Previously he was chief metallurgist and assistant engineer of tests, Chicago, Milwaukee, St. Paul & Pacific Railroad.

H. N. Arbuthnot, assistant to the president, Allegheny Ludlum Steel Corp., has been transferred from Detroit to Washington, D. C. A veteran of 35 years in the steel industry, he is given much credit for the introduction of stainless steel as trim for the modern automobile.

Dr. *Warren S. Peterson* will supervise the physical metallurgy laboratory of the new Kaiser aluminum research department at the company's Trentwood rolling mill near Spokane. He will be concerned at first with a study of the fundamental chemical problems of aluminum reduction and fabrication. For several years he was assistant chief process metallurgist with the Aluminum Co. of America. *E. Wayne Everhart* has arrived at Spokane to take charge of the corrosion laboratory of Permanente's new Kaiser aluminum research department. He spent two years in charge of the corrosion laboratory of the Glenn L. Martin Co., and previously he was with Alcoa. He has specialized in alloy development, X-ray diffraction studies and in corrosion research. He was graduated from Carnegie Tech in metallurgical engineering.

Raymond A. Quadt has been made assistant manager, General Aluminum Dept., Federated Metals Div. He has been in charge of all Federated aluminum research operations at the central research labora-

(Continued on page 129)

News of...

ENGINEERS
COMPANIES
SOCIETIES

ories, American Smelting & Refining Co., Barber, N. J.

Forrest E. Richmond has been elected ice president, Revere Copper & Brass, Inc. nd executive head of that company's Rome, N. Y. division. He has been with Revere ince 1908 and was recently works manager f the Rome division.

Thomas Nast has been elected president nd treasurer, Kensico Tube Co., Mt. Kisco, N. Y., maker of seamless copper tubing. He was with Revere Copper & Brass, Inc. for several years and during the first part of War II was chief of the production section, brass mill branch, WPB.

Graham J. Logan has been made assistant superintendent, McConway & Torley Corp., Pittsburgh, carbon and alloy steel castings and railroad specialties. He has been associated with pattern shop and foundry operations for over 35 years, experience embracing Verona Steel Casting Co. and Fort Pitt Malleable Co. *Paul V. Duffee* has been made chief engineer. For 16 years he was research development engineer with the Ohio Steel Foundry Co.

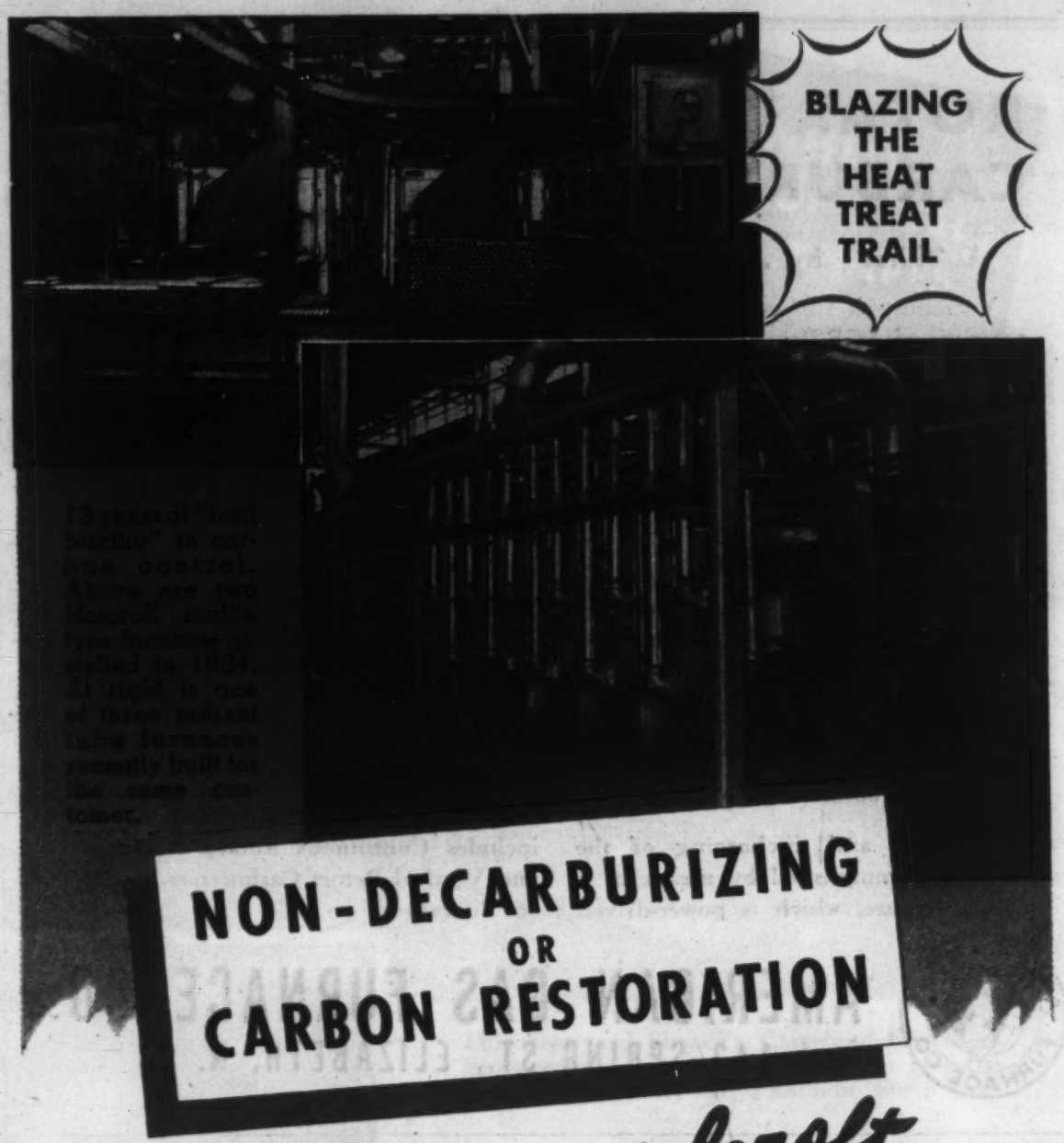
Edwin A. Myers was recently transferred to the Mechanical Development & Engineering Dept., Dow Chemical Co. as a research and development engineer, having been an engineer with the Cellulose Div. *Emmit W. Archer* has joined Dow, acting as research and development engineer in the magnesium laboratory. *Otis R. McIntire* has been made laboratory research director, saran polymerization laboratory, replacing Dr. *G. W. Stanton* who heads a new polymerization laboratory at Pittsburgh, Calif. *Harold G. Le May* becomes research and development engineer of styrene experimental polymerization.

William L. Batt, president, SKF Industries and president, American Society of Mechanical Engineers in 1936, was made an honorary companion of the Order of St. Michael and St. George at a ceremony in the Canadian Embassy in Washington. While serving in high Governmental capacities at Washington during the war he "played an important part in furthering Canadian war production."

George F. Comstock has been appointed assistant director of research for the laboratories of the Titanium Alloy Mfg. Co. For many years he was chief metallurgist of the company.

William H. Taylor has been made director of engineering, Tinnerman Products, Inc., Cleveland, maker of speed nut fasteners. Previous experience was gained with the Budd Mfg. Co., Packard Motor Car Co., Douglas Aircraft and Ford Motor Co.

Dale Torgeson has joined the Research Dept., Harbison-Walker Refractories Co.,



Was a *Holcroft* Development in 1934

The first non-scaling, non-decarburizing furnaces for high carbon steel were installed by Holcroft in 1934. Both are still in operation. Since then, Holcroft has continued the development of non-decarburizing atmospheres responsible for equalizing and restoring carbon in the basic materials.

Today, the advantages of Holcroft controlled-atmosphere hardening are so widely recognized that practically all modern carbon-control furnaces follow one or more of the principles established by Holcroft engineers.

In carbon control, as in every other large-volume heat treat application, Holcroft engineering leadership can serve you *best.* Holcroft offers *complete metallurgical and engineering service,* from designing the furnace to your individual requirements through the trial run of the completed installation. Thus Holcroft assures performance to your exact specifications with maximum over-all economy.

SINCE 1916 *Holcroft* AND COMPANY

BUILT BY HOLCROFT & COMPANY DETROIT-MICH.

PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

6545 EPWORTH BLVD. DETROIT 10, MICHIGAN

CHICAGO 3
C. H. MARTIN, A. A. ENGELHARDT
1017 PEOPLES GAS BLDG.

CANADA
WALKER METAL PRODUCTS, LTD.
WALKERVILLE, ONTARIO

HOUSTON 1
R. E. McARDLE
5724 NAVIGATION BLVD.

ROTARY GAS CARBURIZERS

A "First" by A.G.F. Co.

Versatility is the outstanding characteristic of AGF Rotary Gas Carburizing Furnaces, which may be used not only for carburizing, but also for clean hardening, normalizing, annealing, and other general or atmospheric work without modification to the furnace of any kind.

Uniform heating of the work is assured by the gentle mixing produced by the rotary action of the retort, which is heated by numerous carefully distributed and balanced gas burners. Carburizing or atmosphere gas is introduced through a simply-designed, trouble-free connection.

Charging and discharging of the work is accomplished by means of a tilting feature, which is power-driven on the larger models. The retort remains within the heat at all times.

The furnace shown above is the latest, improved AGF Rotary Gas Carburizer, batch type, with new maintenance-free roller bearing retort support.

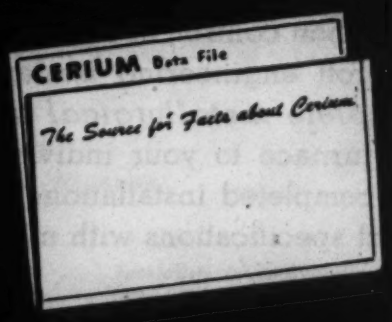
AGF gas carburizing equipment also includes Continuous Rotary Furnaces and Vertical Retort Carburizers. Write for literature.

AMERICAN GAS FURNACE CO.
142 SPRING ST., ELIZABETH, N. J.

A World of Information about CERIUM
(Mischmetal)
In One Convenient File Folder

The latest addition to our CERIUM *Data File is H. Morrogh's* NODULAR GRAPHITE STRUCTURES PRODUCED IN GRAY CAST IRONS describing the use of CERIUM as a desulphurizer and carbide stabilizer in the production of nodular graphite structures.

This informative article is yours on request. The *complete* CERIUM Data File contains, in reference form, most of the known facts about the influence of CERIUM on ferrous and non-ferrous metals. Ask for your copy.



CERIUM METALS Corporation
Pioneer and Largest Producer
Cerium and Cerium Alloys
522 FIFTH AVENUE · NEW YORK 18, N. Y.

News of...

ENGINEERS COMPANIES SOCIETIES

Pittsburgh. He was formerly chief chemist, Northwest Magnesite Co. More recently he has been with the Bureau of Mines at Boulder City, Nev., where he did work on the electric furnace melting of domestic manganese and gaseous reduction of iron ore for production of sponge iron.

Paul M. Keyes has been made an instructor in the Dept. of Mechanical Engineering, State University of Iowa at Iowa City. Previously he conducted time and motion studies for Chicago and Iowa firms. Besides teaching, he will work with Iowa firms in time and motion studies, industrial engineering and production methods.

Ralph F. Koeneman has been appointed assistant chief engineer, Passenger Car Engineering Div., American Car & Foundry Co.'s Berwick, Pa. plant. During the late war he was in ordnance engineering and development, and organized construction of light combat tanks.

G. Klinkenstein, formerly vice president and general manager, Maas & Waldstein, maker of specialized production finishes, has been elected president. He has been with the company since 1915, starting as a chemist in the nitrocellulose plant. As a result of his research the company's products expanded from a few clear metal lacquers to a complete line of industrial finishes.

Curtis A. Gordon has been made general works manager, Jessop Steel Co., Washington, Pa. He was formerly superintendent, Colorado Fuel & Iron Corp., Wickwire Spencer Steel Div., Buffalo, N. Y. He has enjoyed a long experience with several well known steel companies.

Howard M. Hubbard has been elected president, Hydraulic Press Mfg. Co., Mt. Gilead, Ohio. For the past three years he has served as consulting and development engineer, dealing with new products, manufacturing and exporting of heavy power equipment. He has previously served as president of two other nationally known corporations.

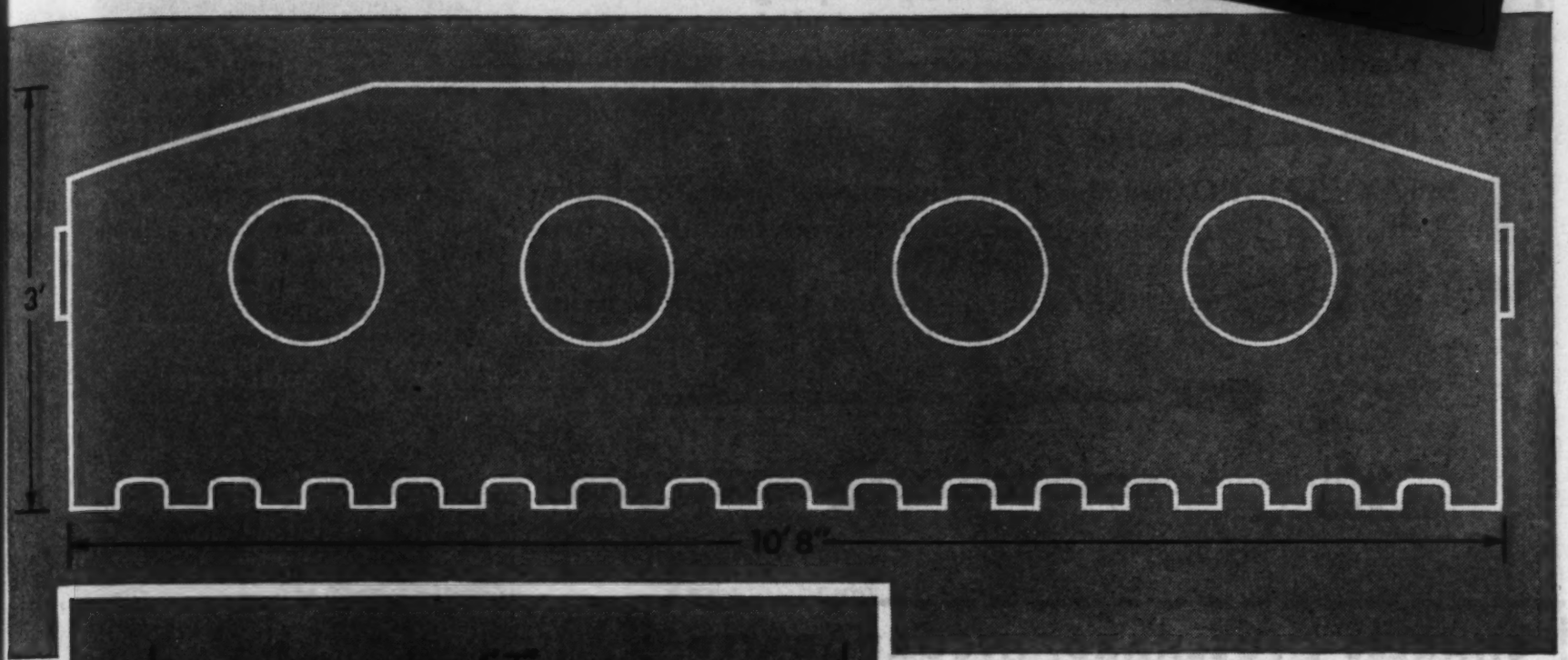
L. P. McAllister has been made manager of steel plants, Lukens Steel Co. He joined the company in 1922 and has served as manager of tests, engineer of tests, metallurgical sales engineer and metallurgical engineer, becoming assistant general manager of steel plants in April, 1947.

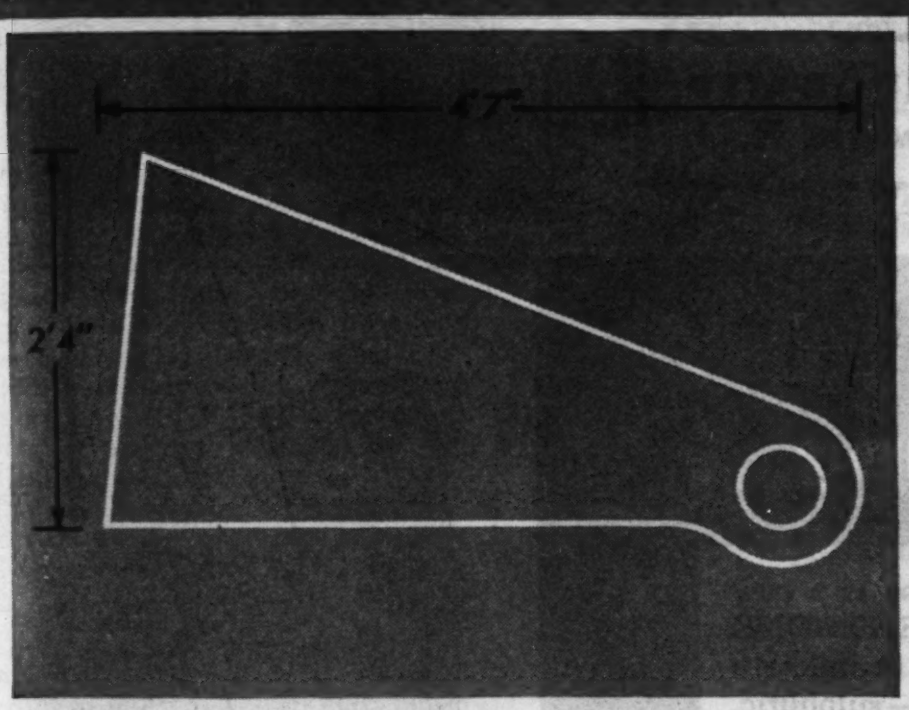
Companies

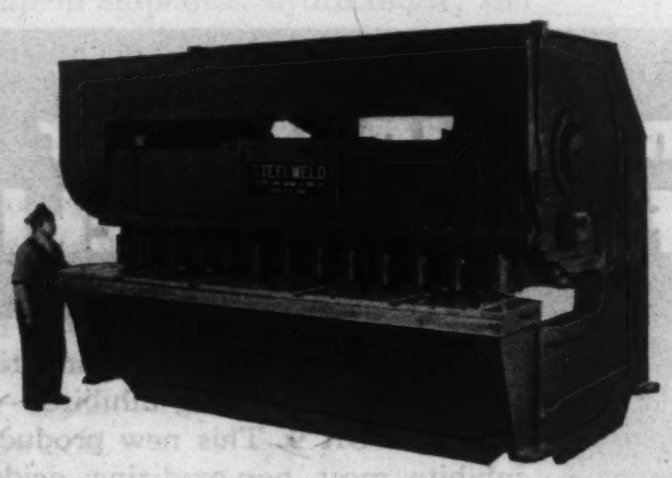
Over 100 foreign students of Rensselaer Polytechnic Institute and Russell Sage College, both of Troy, N. Y., representing 35 foreign countries, Puerto Rico and the

Products are Predictable

...WHEN BUILT OF STEEL PLATE SHAPES







This Steelweld Shear, a Cleveland Crane & Engineering Co. product, is built largely of parts supplied by By-Products Steel Co.

Physical properties of rolled plate are uniformly high. You can pack a lot of strength, therefore, into a minimum of space and weight, with steel plate shapes, just as in this Steelweld Shear—strength on which you can depend.

Many users of steel plate shapes like to buy them from By-Products Steel Co.—carbon, alloy and clad steel shapes. We do the initial cutting to shape and forming operations, sending you the parts for assembly. Scrap goes direct to Lukens open hearths to make more steel. The buyer's facilities are freed for other production and he saves on shipping and scrap handling costs.

By-Products Steel has over 150 major machines for flame-cutting, shearing, pressing, blanking, bending or other shaping operations. We have thousands of dies on hand, so can often save you the cost of new dies.

Bulletin 270 describes the wide range of shaping done in our plants. For a copy, write By-Products Steel Co., Division of Lukens Steel Company, 419 Strode Avenue, Coatesville, Pennsylvania.

LUKENS
BY-PRODUCTS STEEL DIVISION

BY-PRODUCTS STEEL CO.

STEEL PLATE SHAPES

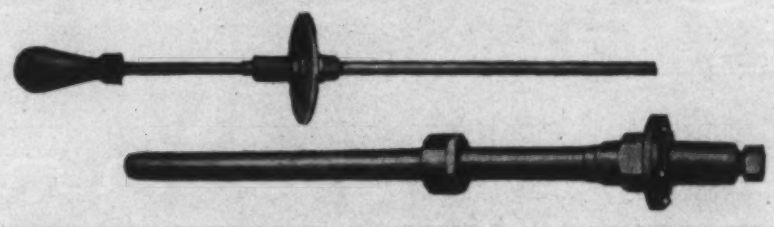
FLAME-CUT ★ SHEARED ★ PRESSED ★ BENT ★ BLANKED ★ WELDED

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

Engelhard
THERMOCOUPLES

- ENGELHARD manufactures a complete range of assembled thermocouples consisting of thermo-elements with insulators, protection tubes, terminal heads, couplings and various accessories. Thermo-elements may be platinum vs. 90% platinum 10% Rhodium, Reclaimed Platinum vs. Platinum Rhodium, Chromel vs. Alumel, Iron vs. Constantan and Copper vs. Constantan.
- ENGELHARD assembled Thermocouples insure maximum efficiency from their pyrometer instruments because each is made up from selected individual parts, chosen because of their ability to meet the requirements of a specific application.

Take your thermocouple problems to ENGELHARD



CHARLES ENGELHARD, INCORPORATED
850 Passaic Ave. • East Newark, N. J.

new inhibitor for bright pickling

- Now available for the first time is a new type of liquid pickling inhibitor—ENTHONE INHIBITOR 9. This new product completely inhibits most non-oxidizing acids—sulphuric, hydrochloric, hydrofluoric and phosphoric. Scale is beautifully and completely removed from steel wire, sheets, rods and finished work, leaving them clean and bright.

Inhibitor 9 is clean and has no odor. It dissolves easily, stops fuming, lowers surface tension for better wetting and displacement of oil films. It is free-rinsing and saves acid by 20% less drag-out plus 99% less attack on steel. *It has every feature required for a perfect inhibitor.*

Would you like a sample to prove these claims for yourself? If so, write today.

METAL FINISHING CHEMICALS
442 Elm Street • New Haven, Conn.

News of...

ENGINEERS COMPANIES SOCIETIES

Canal Zone, attended in May an international students day celebration sponsored by *W. & L. E. Gurley,* Troy, century-old manufacturer of engineering and scientific instruments. They were addressed by Waldo G. Bowman, editor, *Engineering News-Record,* who said that restraints to freedom which require handwork when machines will do the job better are at the root of low living standards in the world. The United States has 7 hp. of mechanical power per capita against 2 hp. 50 years ago. In most countries there is under 2 hp. The visitors inspected the Gurley foundry, toolroom, machine shop, plating, optical and collimator departments.

A tonnage oxygen producing plant to supply the Belle, W. Va., plant of E. I. du Pont de Nemours & Co. will be built and operated by the *Linde Air Products Co.* The output will be 360 tons, or 9,000,000 cu. ft. a day, 95% pure. Linde also contracted recently to supply the Wheeling Steel Corp. at Steubenville, Ohio, with oxygen.

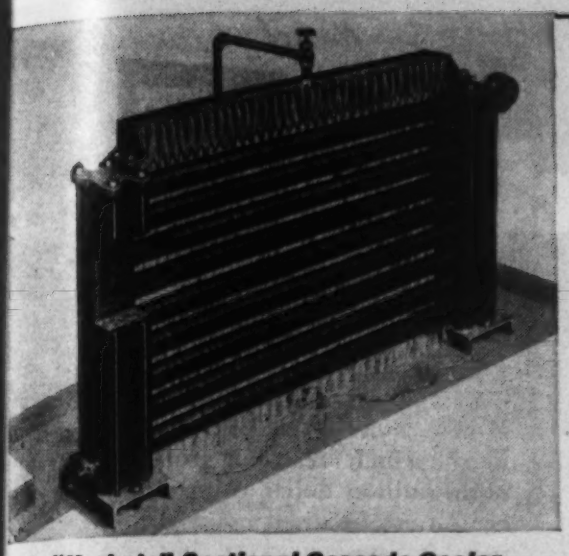
Allis-Chalmers Mfg. Co. has by now adapted the "lost wax," or precision investment castings technique, to many new applications such as for food processing equipment, intricate cams, levers and thread guides for industrial sewing machines and other parts of metals ranging from aluminum bronzes and gray iron to special high temperature alloys. A common job is blades for coal burning locomotive gas turbines, some 10 in. long. The company has developed automatic cycle machines for mass production of patterns and a machine for work involving constant interchange of dies of unusual size or shape.

The *J. F. Reed Mfg. Corp.* has been formed by J. F. Reed, Jr. to design and manufacture plating and heat treating racks and accessory equipment at 286 Hamilton St., New Haven, Conn.

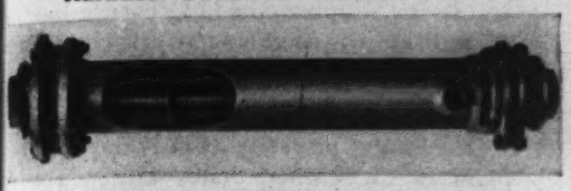
Federal Tool & Mfg. Co., Minneapolis, maker of short-run stampings, has moved into a new plant at 3600 Alabama Ave., St. Louis Park, Minneapolis 16.

The *Aluminum Co. of America* will erect an aluminum producing plant at Point Comfort, near Port Lavaca, Texas, a feature being that it will use natural gas for generation of electric power, the first time Alcoa has used other than water power. Among installations will be a smelting or reduction plant with two potlines in which metal will be produced from purified aluminum ore; a plant for making carbon electrodes; a power plant; and general service facilities. Four to 6 lb. of bauxite will make 2 lb. of alumina, which makes 1 lb. of metal. Also needed are ¾ lb. of carbon, 10-kw. hr. of electricity and other materials.

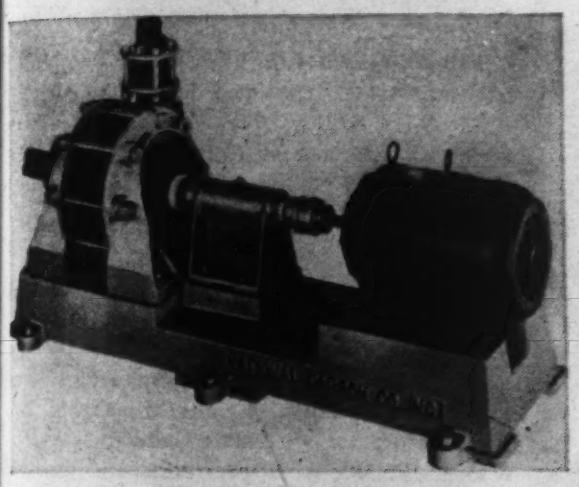
United States Steel Corp. has turned out



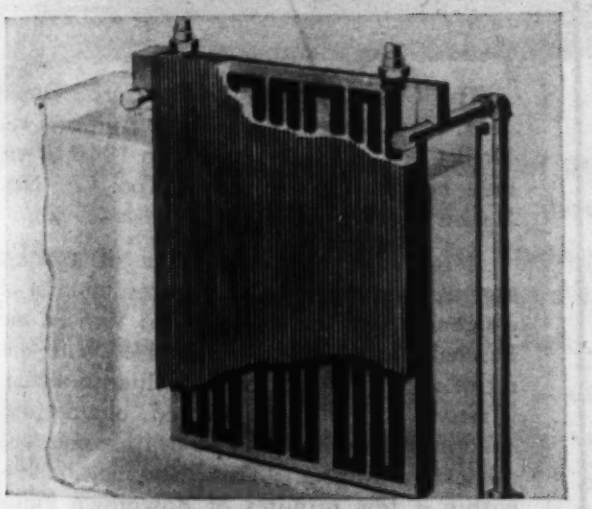
"Karbate" Sectional Cascade Cooler



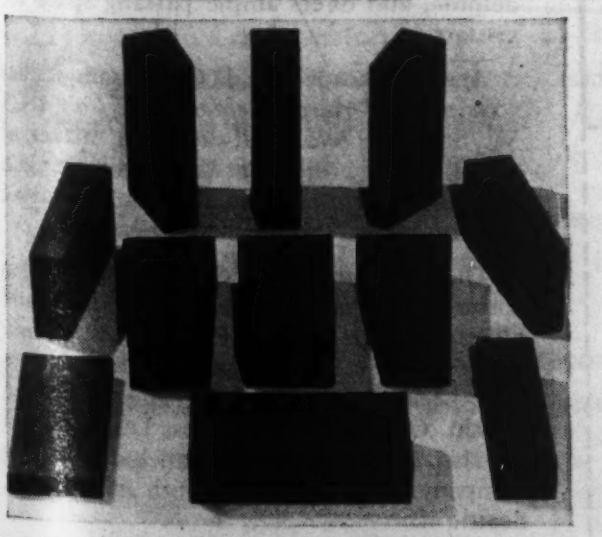
"Karbate" Series 70 Heat Exchanger



"Karbate" Pump



"Karbate" Plate Heater



Carbon Brick for Tank Lining

How to lick corrosion if you pickle or plate metal . . .

USE NATIONAL CARBON PRODUCTS

FOR HEATING, cooling, pumping, and conveying the corrosive solutions used in pickling and plating metal, there's no better equipment than that made of "Karbate" brand Impervious Graphite. This material is chemically inert, immune to thermal shock, easy to machine and install, light in weight yet strong; and has a very high heat-transfer rate.

Operating experience has proved that "Karbate" equipment stands up in sulphuric, hydrochloric, and nitric-hydrofluoric pickling solutions . . . Parkerizing and Bonderizing baths . . . nickel, copper, tin, and zinc plating solutions . . . electro-polishing and Alumilite and Alzak processes.

"National" carbon brick is now extensively used for lining tanks that handle corrosive solutions — particularly nitric-hydrofluoric.

For more details on metal-cleaning systems of standard "Karbate" brand Impervious Graphite units and "National" carbon brick, write to National Carbon Company, Inc., Dept. MM.

These products sold in Canada by Canadian National Carbon Company Limited, Toronto 4

The registered trade-marks "Karbate" and "National" distinguish products of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

30 East 42nd St., New York 17, N.Y.

Division Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

WHAT *do you want* *in a* CASTING INVESTMENT?

1. ECONOMY
2. SIMPLICITY
3. ACCURACY
4. DEPENDABILITY

CRISTOBALITE
FERROLITE

Offer all 4

For your investment—and all your precision casting needs —get in touch with

I.SHOR

64 W. 48th St., New York 19

Dep't M

PRECISION CASTING SALES AND ENGINEERING

A Little Means a Lot

It is only necessary to add small amounts of Cerium Metal (Mischmetal) to molten metals in order to obtain all of its beneficial results. It will help improve the physical properties of many ferrous and non-ferrous materials.

GCC CERIUM METAL
(MISCHMETAL)

The composition of GCC Metal is under our constant laboratory control, which keeps Cerium content at a maximum, between 50% and 55%, and the iron content, impurities and enclosures at an absolute minimum.

● *Keep abreast with the Metallurgical Developments of Cerium Metal. Send for our informative bulletins.*

GENERAL CERIUM COMPANY
1030 RIVER RD., EDGEWATER, N. J.

Please send me the informative bulletins about Cerium Metal.

Name .....

Title .....

Firm .....

Address .....

City ..... State.....

GENERAL CERIUM CO.
EDGEWATER, NEW JERSEY

News of...

ENGINEERS COMPANIES SOCIETIES

a new motion picture, "Unfinished Business", which describes from V-J Day the multi-million dollar construction and modernization program. Actors for the most part are steel workers, but real life portrayals are supplemented by characterizations of well-known stage and screen performers. The Jam Handy organization made the movie.

The only privately-owned tin smelting plant in the United States will be erected by the *Vulcan Detinning Co.* at Sewaren, N. J., near Woodbridge, costing $400,000.

Martin-Quaid Co., alloy metal fabricator, has moved to new and larger quarters at 1815 W. Sedgley Ave., Philadelphia. The company specializes in the fabrication and production of shapes made from stainless steel, aluminum, brass, bronze, copper, steel, alloys, etc.

The *Superweld Corp.*, 708 Hawthorne St., Glendale 4, Calif., has been organized with a capitalization of $500,000 to do electric copper brazing of steel, localized heat silver brazing, bright annealing, and manufacture of specialized metal products. Walter T. Wells is president and general manager. Its furnaces are the largest and most modern for their purposes west of Detroit, they claim.

The *Greenfield Tap & Die Corp.*, Greenfield, Mass., has purchased the Ampco Twist Drill Corp., Jackson, Mich. In 1944 Greenfield bought the Geometric Tool Co., New Haven, Conn.

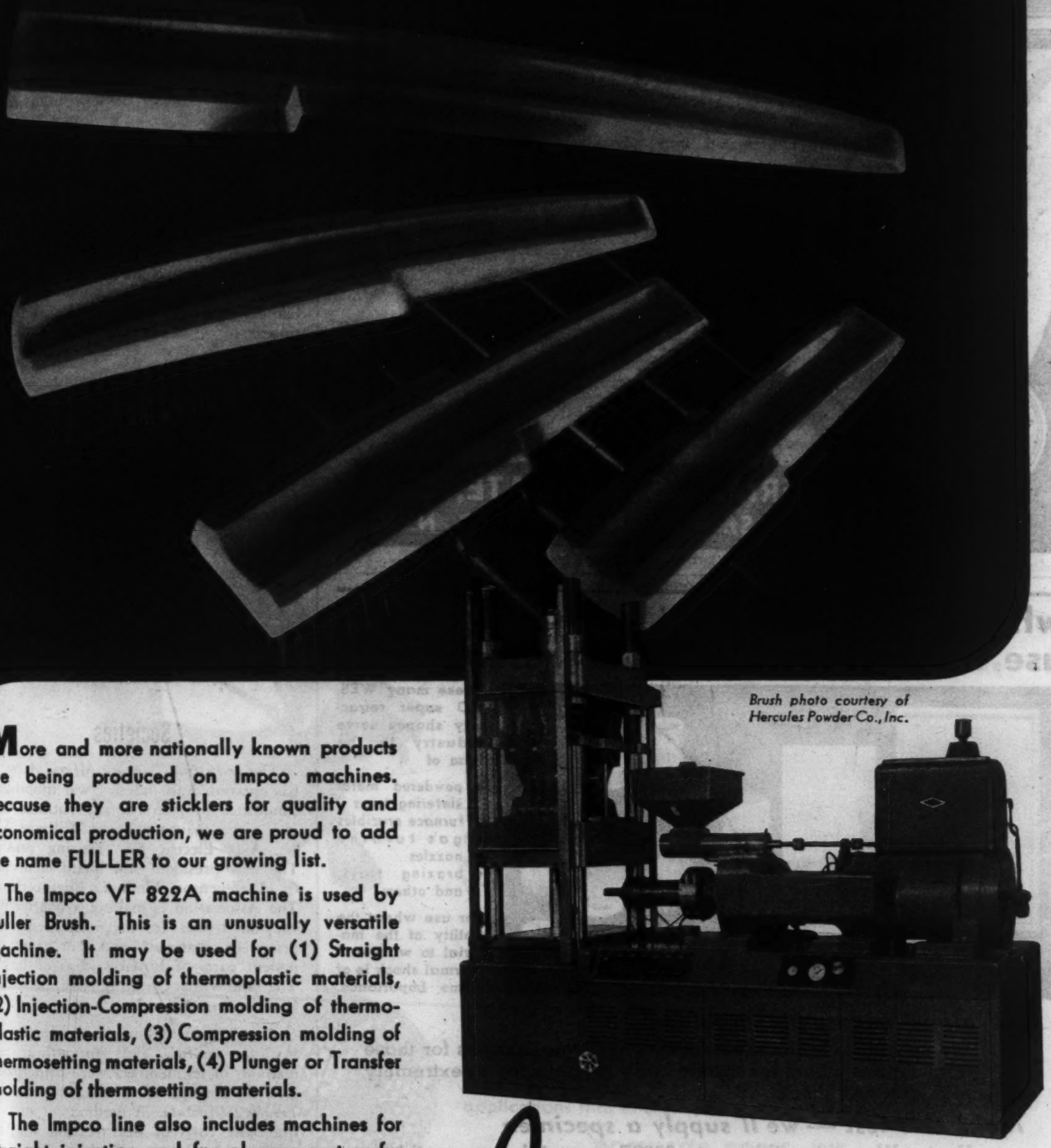
Arcos Corp., manufacturer of stainless and alloy electrodes, announces removal of its general offices on May 1, to 50th St. and Paschall Ave., Philadelphia 43. With this move all Arcos activities, including administrative, sales, research and engineering, and production, will be co-ordinated in one modern building. This new location is within a few minutes of downtown Philadelphia, and offers ample parking space for visitors.

A group headed by J. C. Wilson, Jr. has acquired the *Acro Welder Mfg. Co.*, 1825 W. St. Paul Ave., Milwaukee 3, maker of spot, seam, projection and portable gun resistance welding machines and brazing machines.

The *Associated Lead & Zinc Co.* has been formed to manufacture lead oxides and allied products for the Pacific Coast, a new plant to be located adjacent to the *Northwest Lead Co.* on Harbor Island, in Seattle, Wash. Officers of Northwest Lead Co. will be also management personnel of the new company, located at 2700 16th Ave., S. W., Seattle 4.

(Continued on page 138)

on the job for Fuller Brush



Brush photo courtesy of Hercules Powder Co., Inc.

More and more nationally known products are being produced on Impco machines. Because they are sticklers for quality and economical production, we are proud to add the name FULLER to our growing list.

The Impco VF 822A machine is used by Fuller Brush. This is an unusually versatile machine. It may be used for (1) Straight injection molding of thermoplastic materials, (2) Injection-Compression molding of thermoplastic materials, (3) Compression molding of thermosetting materials, (4) Plunger or Transfer molding of thermosetting materials.

The Impco line also includes machines for straight injection and for plunger or transfer molding.

Our representative will gladly recommend a machine that meets *your* exact requirements.

MP-11

Impco

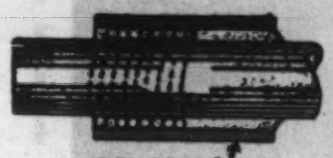
PLASTIC MOLDING MACHINERY DIVISION

Improved Paper Machinery Corporation

Nashua, New Hampshire

VITREOSIL (Vitreous Silica)

TUBES FOR GAS ANALYSES



● Unsuitable, unprotected iron tubes may nullify your gas sampling, introduce serious errors. Vitreosil (Vitreous Silica) tubes avoid all danger of contamination. They cannot rust. They are indifferent to thermal shock; chemically inert, non-porous. When properly protected, Vitreosil tubes give long life. May be water-cooled.

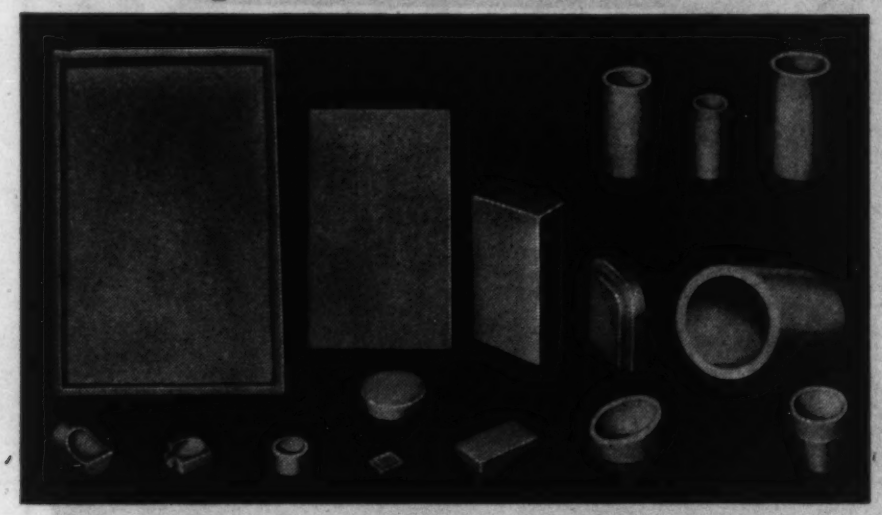
● The use of Vitreosil for Gas Sampling is fully covered in Vitreosil Bulletin No. 3. We will be glad to send you a copy; also to answer any specific questions you may care to ask us.

VITREOUS SILICA — VITREOSIL — REG'D TRADE MARK

Write for Bulletin 3.

THE THERMAL SYNDICATE, LTD.
12 East 46th St. • New York 17, N. Y.

when the heat's *ON and OFF* . . . use dependable WESGO refractories



These many WESGO super refractory shapes serve industry in the form of

- **powdered metal sintering trays**
- **furnace crucibles**
- **gas turbine nozzles**
- **brazing trays, and others**

For use where the ability of the material to withstand thermal shock is of prime importance.

Have you a ceramic problem?

We specialize in the manufacture of special shapes for those applications where a ceramic body is subjected to extremely high thermal shock.

Make this test — we'll supply a specimen

Heat a Wesgo crucible up to 2000F as rapidly as possible— then plunge it immediately into cold water. It won't crack or spall or otherwise suffer damage!

Write for quotations and samples, outlining service conditions. Descriptive booklet on request.

WESTERN GOLD AND PLATINUM WORKS
589 Bryant Street • San Francisco 7, Calif.

News of...

ENGINEERS COMPANIES SOCIETIES

Ampco Metal, Inc., Milwaukee 4, has appointed the *Bay State Bronze & Aluminum Co.*, 191 S. Main St., East Longmeadow, Mass. as an Ampco licensee, authorized to produce castings from Ampco metal ingot.

The *Brown Instrument Co.*, Philadelphia, has launched a $2,500,000 expansion program that will add more than 60% to its present manufacturing space.

Harry L. Showalter, Jr. has formed his own company, *Girard Associates*, specializing in sales and engineering related to the forge and press shop field and involving hammers, presses, heat-treating and vibration control equipment. The company's headquarters is at 417 Lincoln Way West, Chambersburg, Pa.

A new 4-stand tandem rolling mill has gone into operation at the Gary, Ind. sheet and tin mill of the *Carnegie-Illinois Steel Corp.*. This 54-in. mill can roll coils up to 48 in. wide and is adaptable for both sheet and tin plate. It can roll 48,000 lb. hot rolled coils into finished gage at over ½ mile a min.

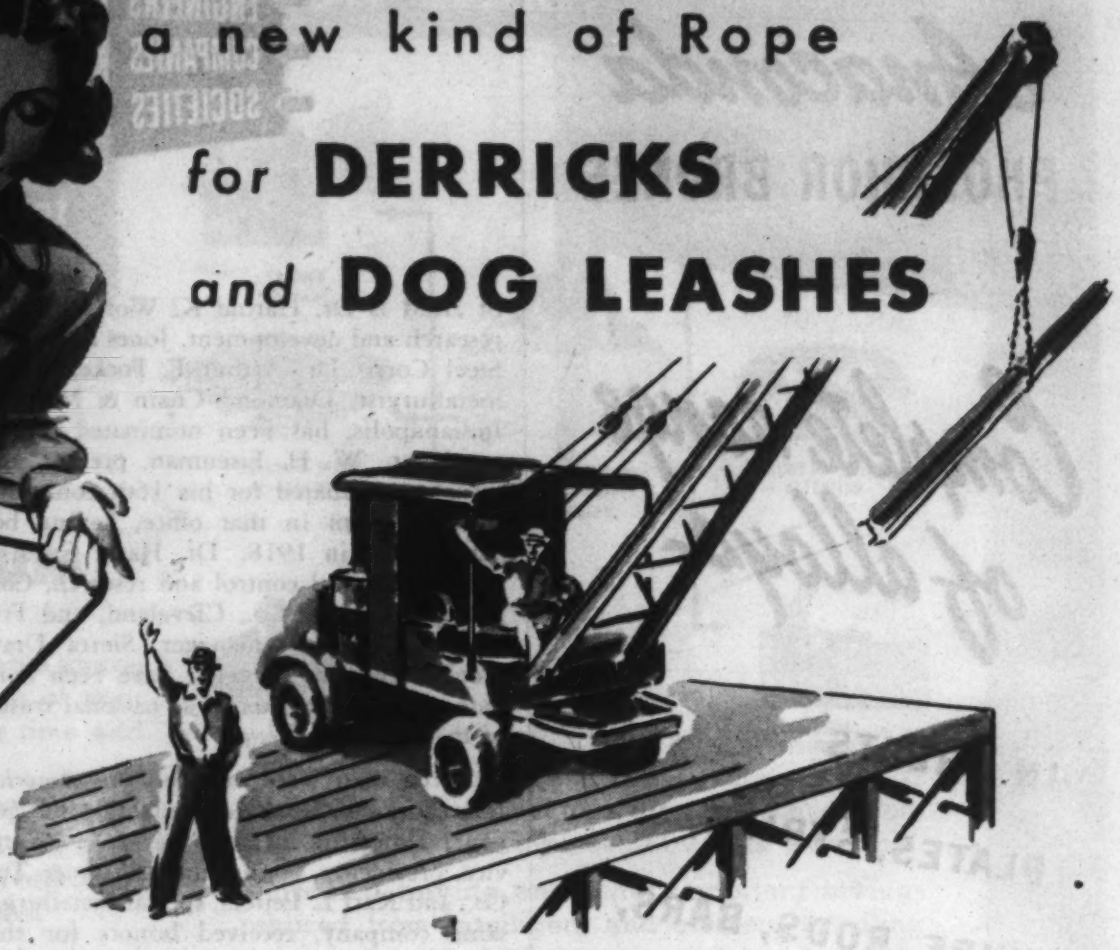
Societies

The *Industrial Furnace Mfgrs. Assn., Inc.* has appointed an industry war mobilization committee to plan for any national emergency, the chairman being William Adam, Jr., Ajax Electric Co., retiring president. The new president and board chairman is C. H. Stevenson, Lindberg Engineering Co. The Association is making a quarterly survey on trends of inventories, deliveries, prices of materials and purchased component parts of furnaces; also of business. The mid-winter meeting will be held in Cleveland in January.

Plans for increasing the market for heat-treating services and improving selling methods of its members were principal subjects at the spring meeting of the *Metal Treating Institute*. A method for determining basic costs of heat-treating was made available to the membership. The annual meeting will be held at the Adelphia Hotel, Philadelphia, Oct. 22-25, or prior to the opening of the Metal Show of the American Society for Metals.

The thirtieth annual *National Metal Congress* and *Exposition of the American Society for Metals* will be held in Philadelphia's Commercial Museum and Convention Hall, Oct. 23-29. Nominated for president

There's a new kind of Rope for DERRICKS and DOG LEASHES



Made in a wide range of
strengths and flexibilities —
with entire cable
nylon covered as shown above,
or with each individual strand
nylon covered

(and maybe your product, too)

A lot of products are going to be better because there's a new kind of rope. Some are products where wire rope's been used for years. Many more are products where it's never been used before. Don't be surprised if your product turns up among them — or if your plant is one where Rochester Nylon-Wire Rope will cut production costs.

On derricks, for instance, this new Rochester rope may possibly prove to have far more endurance than any all-steel lines.

To dog leashes, tiller cables and scores of other products, this same rope with its tough, solid-plastic coating adds safe, easy-to-handle smoothness, along with corrosion resistance, glowing style, and long, satisfactory life.

This new rope should be considered for use wherever a supple member must withstand friction, flexing, air or water drag. In many places, it will survive far more bending, far more pulley wear, abrasion and abuse than any other product yet known.

Write for samples, prices, and test data pertinent to the applications that interest you.

ROCHESTER ROPES, INC.
540 Water Street, New York 2, N. Y.

ROCHESTER *Nylon+Wire* ROPES

Anaconda
PHOSPHOR BRONZE

Complete range of alloys

IN SHEETS
PLATES, STRIPS,
WIRE, RODS, BARS,
SEAMLESS TUBES &
SPECIAL SHAPES

The American Brass Company offers Anaconda Phosphor Bronze in 10 standard compositions (including a free-cutting alloy) with tin content ranging from 1.25 percent to 10.5 percent.

Tell us what you make and how it's used. Our Technical Department is at your service in helping you select the correct alloy, the most serviceable temper, the most economical form. 48080

ANACONDA
from mine to consumer

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Co.
In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*

HIGH
TENSILE STRENGTH
ELASTIC LIMIT
RESISTANCE TO FATIGUE
RESISTANCE TO CORROSION
RESISTANCE TO WEAR

News of...

ENGINEERS COMPANIES SOCIETIES

of ASM is Dr. Harold K. Work, manager, research and development, Jones & Laughlin Steel Corp. Dr. Arthur E. Focke, research metallurgist, Diamond Chain & Mfg. Co., Indianapolis, has been nominated for vice president. W. H. Eisenman, present secretary, is nominated for his 16th consecutive two-year term in that office, having been first elected in 1918. Dr. Harry Croft, director, technical control and research, Chase Brass & Copper Co., Cleveland, and Frederick J. Robbins, manager, Sierra Drawn Steel Corp., Los Angeles, have been nominated for two-year terms as national trustees of the ASM.

Three men were awarded the *American Iron & Steel Institute* medal at the 56th general meeting in late May. J. L. Mauthe, vice president, Youngstown Sheet & Tube Co., and Karl L. Fetters, special metallurgist, same company, received honors for their 1947 technical paper, "The Mineralogy of Basic Open Hearth Slags." The late J. H. Slater, who had been with Republic Steel Corp. at the time of his death, was honored posthumously for his 1947 paper, "Operation of the Iron Blast Furnace at High Pressure."

The *Copper & Brass Research Assn.* has taken in two new members, both redrawers of copper products, making the total membership 46. They are the Small Tube Products, Inc., Waterbury, Conn., and the Drawn Metal Specialty Co., Inc., Thomaston, Conn.

The committee on cast iron microstructure of the *American Foundrymen's Assn.* has begun preparation of a comprehensive analysis of metallographic techniques for iron now in general use. Among topics covered will be general background; cutting and mounting; grinding, polishing and etching; photomicrography, developing and printing; and special "tricks of the trade." The committee finds that metallographic techniques for cast iron are still an art, with success in polishing depending largely on the operator's skill. The committee chairman is H. W. Lownie, Jr., research engineer, Battelle Memorial Institute.

The *Porcelain Enamel Institute* has arranged a tentative program for its tenth annual forum at the University of Illinois, Urbana, Oct. 13-15. Two panel discussions will involve development, properties and applications of titanium enamels; and application of porcelain enamel cover coats directly to steel. The Armed Forces have been invited to contribute to the program and research progress at the National Bureau of Standards will be reported. A quiz program to stump the experts will be an unusual feature.

The *Massachusetts Institute of Technology*

"THERE JUST ISN'T ANY 'ONE-SHOT' CUTTING FLUID"

...says "CHIP" WRIGHT

"You know, I've been around shops a long time and I've seen more than one man who thought he had a cutting fluid that could be used for everything. But, it just doesn't work that way. When you overdo standardization or simplification, trouble develops. Speeds, feeds, materials, tolerance and finish requirements all help determine the correct cutting fluid for the job. Because of this, I have found it best to rely on the recommendations of experienced cutting oil people. It's false economy to over-standardize or over-economize when it comes to cutting fluids."

—Chip

A Word About SOLVOL water-mixed cutting compound

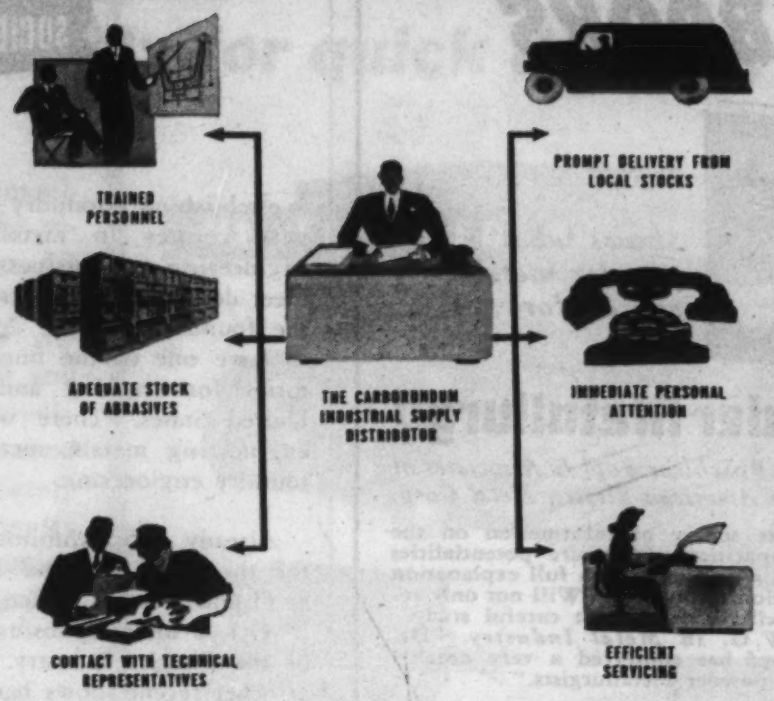
SOLVOL, D. A. Stuart Oil Company's modern water-mix compound, will solve some of your machinery problems, eliminate some of your headaches. SOLVOL is more than just a high grade emulsifiable cutting fluid. It is a unique product incorporating extra cutting qualities which enable it to perform metal cutting jobs beyond the scope of other soluble products. Write for SOLVOL Booklet.

Another Time-Tested Stuart Product

D. A. Stuart Oil CO.
2745 SOUTH TROY STREET, CHICAGO 23, ILL.

A BUYING GUIDE FOR ABRASIVES

ABRASIVE PROBLEM:
Where is there a convenient Source of Supply?



ANSWER BY

CARBORUNDUM
TRADE MARK

As an efficient and dependable source of supply, the services and facilities of your CARBORUNDUM distributor offer time and money saving advantages.

From large and varied stocks of abrasives located conveniently nearby, the products you need are available without delay. Plant inventories can be safely and economically reduced.

Frequent personal service by a trained and experienced local staff provides reliable facts and figures on abrasive applications and operations.

On difficult or unusual jobs, direct assistance from CARBORUNDUM representatives is available.

Simplified buying and other important savings realized from intelligent and efficient handling are creating an increasing preference for abrasives by CARBORUNDUM. The Carborundum Company, Niagara Falls, New York.

CARBORUNDUM
TRADE MARK

BONDED ABRASIVES
COATED ABRASIVES
ABRASIVE GRAINS AND FINISHING COMPOUNDS

Specialized wheels by CARBORUNDUM for thread grinding
Diamond wheels to meet stiffer technical needs
A coated abrasive for every grinding and finishing condition
All standard shapes are supplied in grinding wheels by CARBORUNDUM

"Carborundum" is a registered trade-mark which indicates manufacture by The Carborundum Company

PROFITABLE BOOKS

Shows what powder metallurgy can do for you

Powder Metallurgy

By P. Schwarzkopf & Associates of the American Electro Metal Corp.

A complete source of information on the present capacities and future potentialities of powder metallurgy, with full explanation of production techniques. "Will not only repay but will demand most careful study," says H.W.G. in *Metal Industry*. "Dr. Schwarzkopf has conferred a very notable benefit on powder metallurgists."

1000 production aids

Illustrated Jig-Tooling Dictionary

By T. G. Thompson & R. A. Peterson

988 clear working drawings, with concise explanations, graphically demonstrate the construction and use of all basic tooling equipment. Full tables of pertinent data included. A highly useful reference for tool and production departments.

How to do it the best and easiest way

Simplified Punch & Diemaking

By James Walker & C. C. Taylor

Explains each step in the design, construction and use of all types of dies and punches for fabricating sheet metal. Includes information on the latest and best methods and materials. This book will help you get your good ideas into production.

SEE THEM ON APPROVAL

The Macmillan Co., 60 Fifth Ave., N. Y. 11.
Please send me on 10 days' approval copies of the books checked below.

- ☐ **Powder Metallurgy $8.00**
- ☐ **Illustrated Jig-Tooling Dictionary $7.50**
- ☐ **Simplified Punch & Diemaking $5.00**

*Signed*_____

*Address*_____

*City & State*_____

News of...

ENGINEERS COMPANIES SOCIETIES

is establishing a foundry program combined with courses in metallurgy, mechanical engineering and business administration to meet demands for professional training for the foundry industry. M.I.T. is ambitious to have one of the finest foundry laboratories for teaching and research in the United States. There will be courses on engineering metals, metal processing and foundry engineering.

Already 105 exhibitors have signed up for the third *National Plastics Exposition* at Grand Central Palace, New York, Sept. 27-Oct. 1 under sponsorship of the Society of the Plastics Industry. Buyer attendance at other recent shows has exceeded 30,000, and it is expected that next September's attendance will exceed that.

John J. Lincoln, Jr., director of sales services, Air Reduction Sales Co., New York, has been elected president, *International Acetylene Assn.*, having previously served as vice president and member of the executive committee.

The *Gray Iron Founders' Society, Inc.* quotes the Bureau of the Census to the effect that in March the gray iron industry shipped 1,169,085 net tons of cast components, a new all-time high for a month and exceeding the best month of the war by 37%. According to a recent survey of the industry, there are 2500 gray iron foundries in this country, located in all states except one.

A short refresher course in sales engineering of machine tools is being held at Cornell University, Ithaca, N. Y., July 12-23 under joint sponsorship of the *Sibley School of Mechanical Engineering*, the *National Machine Tool Builders' Assn.* and the *American Machine Tool Distributors' Assn.* It is described as the first course offered by a college to emphasize the sale of capital equipment in American industry.

Scientific and technical librarianship will be offered as an option in the Carnegie Library School of the *Carnegie Institute of Technology*, starting in September. The specialized courses include: "Bibliography of Science and Technology" and "Administration of Science and Technology Libraries."

A union list of scientific and technical periodicals in the libraries of greater Cincinnati was published May 1, listing the holdings of 58 public and industrial libraries. It contains 3200 titles and over 10,000 separate entries. This guide was brought out by the Cincinnati section, American Chemical Society. It consists of 125 double column pages, litho-printed, bound in durable paper and is obtainable from Dr. R. E. Oesper, University of Cincinnati, Cincinnati 21.

Charles R. FonDersmith, superintendent,

MORE and BETTER STAMPINGS with *Strenes Metal*

DRAWING AND FORMING DIES

You'll find this book interesting. Ask for it.

Having been brought up the hard way, some engineers and diemakers insist that drawing and forming dies *must* be made out of tool steel. Generally, however, the advantages of contour-cast dies are recognized.

***Strenes Metal* is an alloy with characteristics especially suitable for drawing and forming dies. Proof of this is found in hundreds of cases where *Strenes Metal* dies are delivering an extraordinary number of perfect stampings between redressings.**

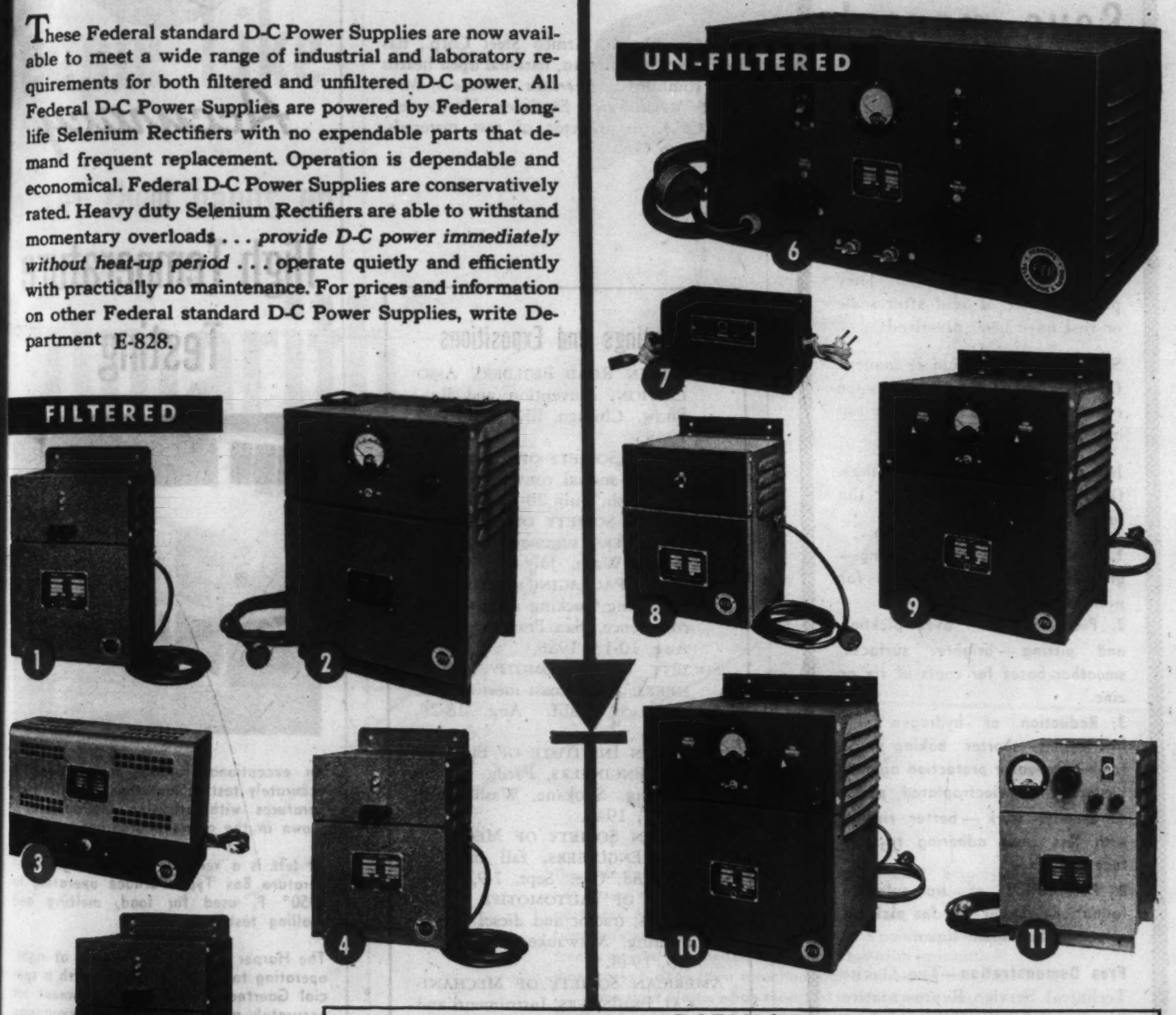
We'll be glad to give you the evidence. The information will show you how to reduce your costs considerably along with improving your product. Tell us what your drawing and forming operations are and we'll tell you honestly what *Strenes Metal* dies will do for you.

THE ADVANCE FOUNDRY COMPANY
109 SEMINARY AVENUE
DAYTON 3, OHIO

FEDERAL STANDARD D-C POWER SUPPLIES...

now in stock and ready for quick delivery

These Federal standard D-C Power Supplies are now available to meet a wide range of industrial and laboratory requirements for both filtered and unfiltered D-C power. All Federal D-C Power Supplies are powered by Federal long-life Selenium Rectifiers with no expendable parts that demand frequent replacement. Operation is dependable and economical. Federal D-C Power Supplies are conservatively rated. Heavy duty Selenium Rectifiers are able to withstand momentary overloads . . . *provide D-C power immediately without heat-up period* . . . operate quietly and efficiently with practically no maintenance. For prices and information on other Federal standard D-C Power Supplies, write Department E-828.



RATINGS

	FILTERED					UNFILTERED					
	A-C Input			D-C Output			A-C Input			D-C Output	
Code Number	Volts	Phase	Cycles	Volts	Amps.	Code Number	Volts	Phase	Cycles	Volts	Amps.
1 FTR 3093-AS	115	1	60	12	3	6 FTR 3300-DS	115	1	60	2-32	50
2 FTR 3128-BS*	115	1	60	22-30	10	7 FTR 1342-AS	115	1	50/60	6	4
3 FTR 3246-BS	115	1	60	6	10	8 FTR 3341-AS	115	1	50/60	28	5
4 FTR 3138-BS	115	1	60	12	5	9 FTR 3339-BS	115/230	1	50/60	6-24	18
5 FTR 3185-AS	115	1	60	12	7.5	10 FTR 3340-BS	115	1	50/60	5-70	12
						11 FTR 3352-BS	115	1	50/60	5/10	20/10

*Filtered and regulated

KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

Federal Telephone and Radio Corporation

SELENIUM and INTELIN DIVISION, 900 Passaic Ave., East Newark, New Jersey

In Canada: Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors: International Standard Electric Corp. 67 Broad St., N. Y.

Save steel! Save acid! Save money!

USE Oakite Pickle Control No. 3 to inhibit hot sulphuric-acid pickling baths! Use Oakite Pickle Control No. 4 to inhibit hydrochloric-acid pickling baths!

Oakite Pickle Controls minimize attack on steel without retarding action on scale or rust. They prevent waste of acid after scale or rust have been dissolved.

Steel is money! Acid is money! Oakite Pickle Controls save some customers up to 19 cents per ton on pickling operations!

In addition to these savings, Oakite Pickle Controls offer the following advantages:

1. Reduction of acid fuming—greater safety and comfort for workers.

2. Prevention of over-pickling and pitting—brighter surfaces, smoother bases for coats of tin or zinc.

3. Reduction of hydrogen embrittlement—shorter baking time for wire, greater protection against blistering of electroplated parts.

4. Cleaner work—better rinsing with less smut adhering to surfaces.

5. Retardation of iron-sulphate formation—longer life for pickling solutions, less spent liquor.

Free Demonstration—The Oakite Technical Service Representative in your vicinity will gladly demonstrate the efficiency of Oakite Pickle Controls. Also write for new Oakite Special Service Report on "Improved Pickling and Neutralizing".

OAKITE PRODUCTS, INC.
32H Thames Street, NEW YORK 6, N. Y.
Technical Service Representatives Located in Principal Cities of United States and Canada

OAKITE

Specialized Industrial Cleaning
MATERIALS • METHODS • SERVICE

News of...

ENGINEERS COMPANIES SOCIETIES

steel production, Armco Steel Corp., has been elected chairman, national open hearth steel committee, *American Institute of Mining & Metallurgical Engineers.* He succeeds W. C. Kitto, director of raw materials, Pittsburgh Co.

Meetings and Expositions

AMERICAN ROAD BUILDERS' ASSOCIATION, convention and Road Show. Chicago, Ill. July 16-24, 1948.

AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention, Seattle, Wash. July 20-22, 1948.

AMERICAN SOCIETY OF CHEMICAL ENGINEERS, summer convention. Seattle, Wash. July 21-23, 1948.

WESTERN PACKAGING EXPOSITION, packaging, packing and shipping conference. San Francisco, Calif. Aug. 10-13, 1948.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. San Francisco, Calif. Aug. 18-20, 1948.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Pacific general meeting. Spokane, Wash. Aug. 24-27, 1948.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Portland, Ore. Sept. 7-9, 1948.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor and diesel engine meeting. Milwaukee, Wis. Sept. 7-9, 1948.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments and Regulators Div. meeting. Philadelphia, Pa. Sept. 13-17, 1948.

INSTRUMENT SOCIETY OF AMERICA, annual meeting. Philadelphia, Pa. Sept. 13-17, 1948.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Aviation Div. meeting. Dayton, Ohio. Sept. 20-21, 1948.

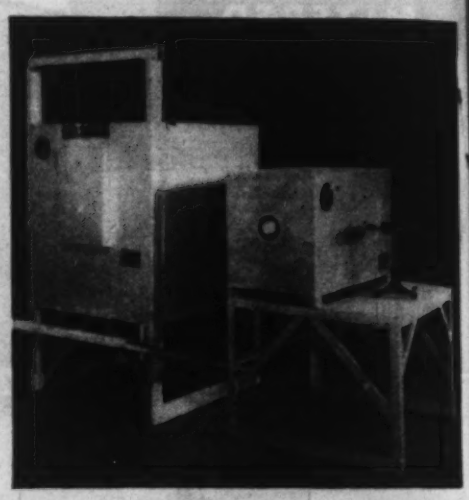
AMERICAN MINING CONGRESS, metal mining show. San Francisco, Calif. Sept. 20-23, 1948.

SOCIETY OF THE PLASTICS INDUSTRY, national plastics exposition. New York, N. Y. Sept. 27-Oct. 1, 1948.

ASSOCIATION OF IRON & STEEL ENGINEERS, annual meeting. Cleveland, Ohio. Sept. 28-Oct. 1, 1948.

Harper

Accuracy In High Temperature Testing



An exceptional furnace installation for accurately testing materials at high temperatures with precision instruments is shown in the above photograph.

At left is a versatile Harper High Temperature Box Type Furnace operating to 2950° F, used for load, melting and spalling tests.

The Harper Creep Test Furnace at right, operating to 2750° F, is used with a special Gaertner Creep Test Instrument for accurately measuring the linear expansion and contraction of 8" specimens. Visible are two observation ports for sighting with the creep test instrument across the ends of the specimen positioned horizontally inside a bonded silicon carbide tube.

For accuracy in your high temperature testing, consult Harper Engineers. Write for data.

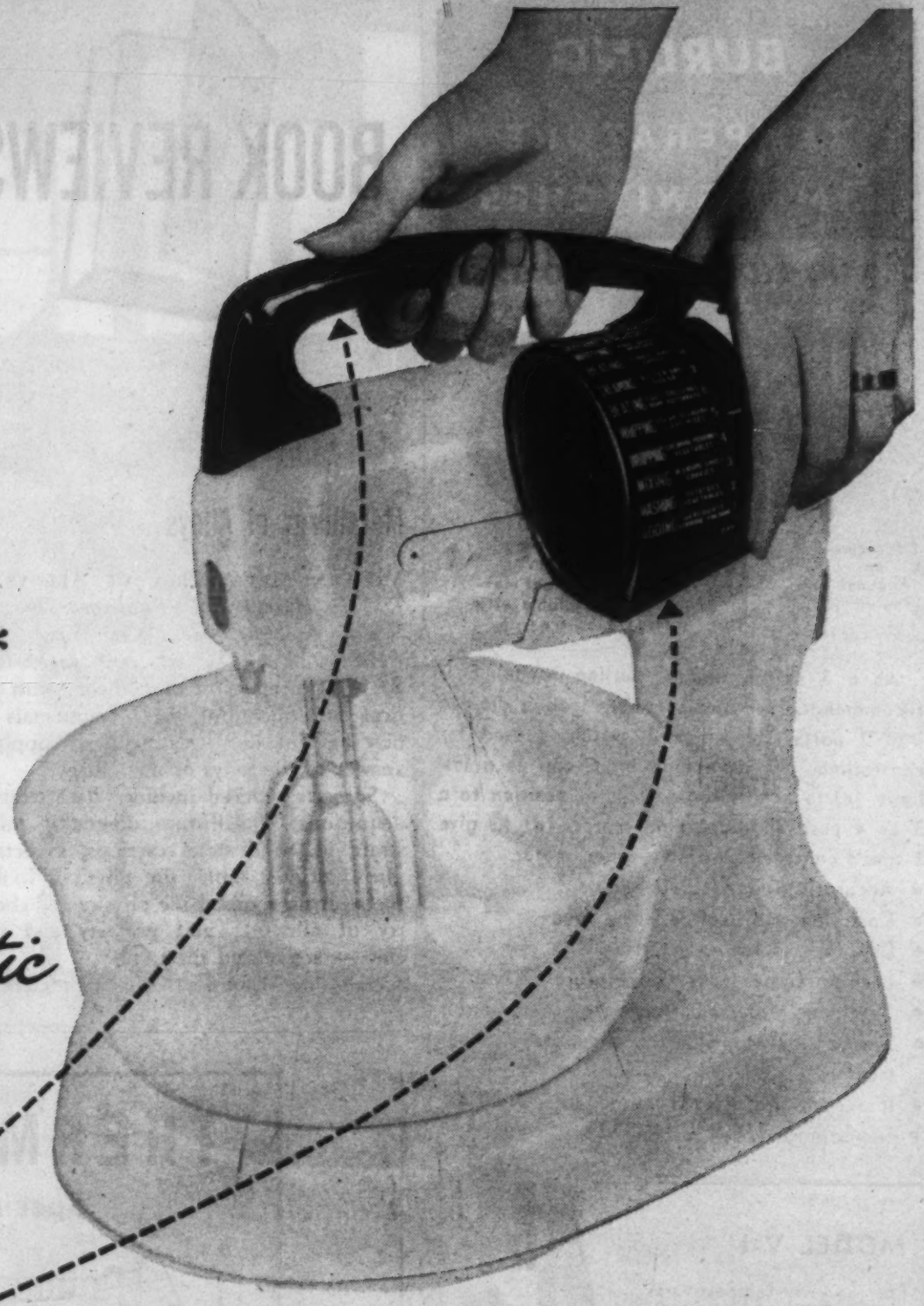
Harper
ELECTRIC FURNACE CORPORATION
1461 Buffalo Avenue
NIAGARA FALLS, N. Y.
Representatives in principal cities

People Like

to get their hands on

Lumarith*

A Celanese Plastic*



The manufacturer of the Dormeyer "Power Chef" employs two types of Lumarith in producing the point-of-contact parts for this popular kitchen mixer. It's an example of Lumarith's versatility. The power indicator guide is molded from a special *heat and flame resistant* Lumarith formulation, that scores high in form retention and dimensional stability . . . is the *right* plastic when electrical product parts need UL approval—plus rugged toughness. Molded by Industrial Plastics, Chicago, Illinois.

IT'S no coincidence that products and parts subject to constant handling are so often molded from Lumarith—Celanese' tough, satin-smooth cellulose acetate.

Lumarith's high insulation qualities—both thermal and electrical offer the utmost in touch-comfort and handling safety. Lumarith's wear-loving surface doesn't attract dust, and it actually grows more lustrous with handling. Lumarith's molded-in color holds its *new look* for the life of the product.

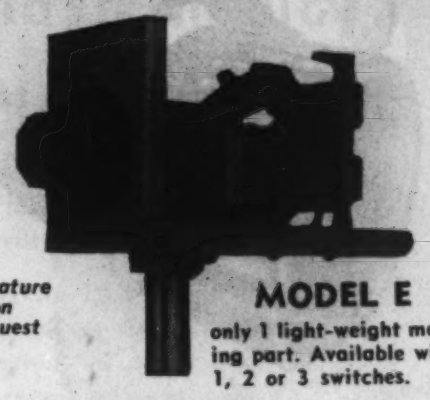
If you have a product that needs a *welcome touch* for consumer acceptance, get in touch with a Celanese representative. He can give you expert technical and practical advice.

CELANESE CORPORATION OF AMERICA
Plastics Division, Dept. D-4
180 Madison Avenue, New York 16, N. Y.

*Reg. U. S. Pat. Off.

BURLING
TEMPERATURE
LIMIT SWITCHES

USE NO LIQUIDS . . . NO GASES



Literature on Request

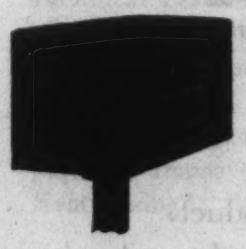
MODEL E
only 1 light-weight moving part. Available with 1, 2 or 3 switches.

As a 3 switch model, Burling Model E is recommended for use (a) where load is divided into 3 parts, (b) where 1 switch is used for controlling, one as a high limit, one as a low limit, (c) to give definite stops or position to a 3 or 4 position diaphragm motor, (d) to give 3 speed control of variable speed motor.

- Accurate, Rugged, Dependable
- Corrosion and heat resisting tube
- Dial Pointer for easy setting
- Locking screw locks temperature setting
- Terminal plate has large screw terminals
- Snap-action Micro-Switch eliminates contact troubles
- Increased Adjustable range to 700-1000°
- Dimensions—7¼" x 2¾" x 3½"

MODEL V-I

For lower temperature range from 0-300°F. Available for minimum of —100° to maximum of 600°F. Usual adjustable range 50-150°, operating differential may be as small as ±¼ or as large as ±5°. Adjustable by screw and dial inside case. (Sizes 2¾" diameter × 4¼" high.)



MODEL D

Adjustable range 200-500°F. Temperature range 0-1400°F. For use where temperature must be changed to suit operating conditions. Turn outside knob to change temperature setting. (Sizes 5½ x 2¾ x 2¾".)

Instruments also Built to Specifications

Making Precision Controls for Over 11 Years

BURLING INSTRUMENT CO.
Springfield Ave. at Livingston St.
Newark, N. J.

BOOK REVIEWS

Metallurgy of Alloys

MODERN METALLURGY OF ALLOYS. *By R. H. Harrington. Published by John Wiley & Sons, Inc., New York, 1948. Cloth, 5¾ x 8¾ in., 209 pages. Price $3.50.* Correlates modern theory with practical data, including the fundamentals of a new field of alloy treatments to supply the answer to the whys of metallurgy.

Subjects covered include: heat treatment definitions; equilibrium diagrams; role of strain vs. solid state reactions; a metallurgist's periodic table; the physicist looks at metallurgist looks at the physics and chemistry of alloying; and porosity and particles — active and inactive.
metals; the chemist looks at metals; the

Simple, standard definitions have been formulated by the author and contribute to the usefulness of this book.

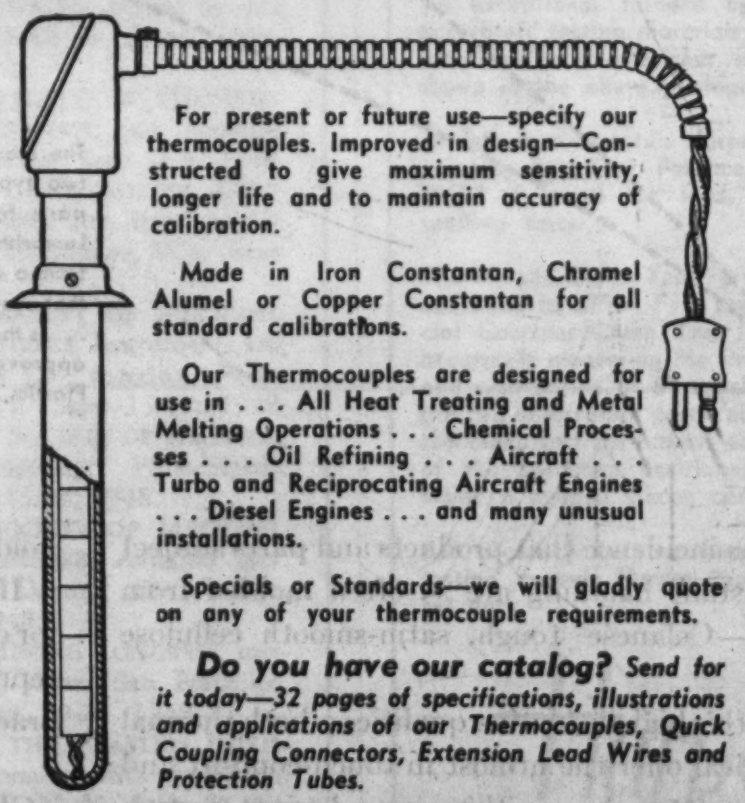
Design of Metal Cutting Tools

DESIGN OF METAL CUTTING TOOLS. *By Frederic L. Woodcock. Published by McGraw-Hill Book Co., Inc., New York, 1948. Cloth, 6¼ x 9¼ in., 406 pages. Price $5.00.* This handbook, based on the experiences and actual practices in high-precision high-production work over a period of 20 years, incorporates rules, formulas and tables of data to aid in the most profitable and efficient design of all metal-cutting tools.

The practical application of the tool to the job, how to salvage worn-out or obsolete tools and convert them to new purposes, how tools are made to function accurately and economically, fundamentals of design (including elements of cutting, materials, heat treatments, etc.) are among the topics discussed.

Practical procedures and easy-to-follow instructions on the design of broaches, cutters, drills, hobs, punches and dies, reamers, etc. are included. Elementary and detailed explanations are given in order to make this handbook also of assistance to students and teachers. It is well illustrated.

THERMOCOUPLES
Special or Standard



For present or future use—specify our thermocouples. Improved in design—Constructed to give maximum sensitivity, longer life and to maintain accuracy of calibration.

Made in Iron Constantan, Chromel Alumel or Copper Constantan for all standard calibrations.

Our Thermocouples are designed for use in . . . All Heat Treating and Metal Melting Operations . . . Chemical Processes . . . Oil Refining . . . Aircraft . . . Turbo and Reciprocating Aircraft Engines . . . Diesel Engines . . . and many unusual installations.

Specials or Standards—we will gladly quote on any of your thermocouple requirements.

Do you have our catalog? *Send for it today—32 pages of specifications, illustrations and applications of our Thermocouples, Quick Coupling Connectors, Extension Lead Wires and Protection Tubes.*

Thermo ELECTRIC CO.
FAIR LAWN, N.J.